NRDC

GOVERNMENT OF INDIA
MINISTRY OF NEW AND RENEWABLE ENERGY

15 CEEW THE COUNCIL

Driving Energy Transition

Workforce, Skills, and Gender in India's Renewable Energy Sector

June 2026

DISCLAIMER

This report presents an independent analysis by the authors. Neither CEEW nor NRDC has any financial or commercial engagement with MNRE. The data used for the analysis have been collected from industry stakeholders through surveys. MNRE's role has been limited to providing technical guidance, and it does not hold ownership of the data. The views expressed are those of the individual authors and do not necessarily reflect the views or policies of MNRE, CEEW and NRDC.

AUTHORS

NRDC:
Deepesh Tourani, Pallavi Girolkar, Rana Pujari
Project Director: Charu Lata

CEEW:
Nicole Almeida, Akanksha Tyagi, Soham Roy (former researcher)
Project Director: Rishabh Jain

CITATION

Almeida et al., Driving Energy Transition: Workforce, Skills, and Gender in India's Renewable Energy Sector, CEEW - NRDC, 2026.

ACKNOWLEDGMENTS

We extend our sincere gratitude to the Secretary, Ministry of New and Renewable Energy (MNRE), for their invaluable guidance throughout the development of this report. We are deeply thankful to Ms Mini Prasannakumar, Deputy Director General, MNRE, for her constant guidance and unwavering support at every stage of this work. We also thank Sangita M. Kasture, Scientist G; Dr Jeevan Kumar Jethani, Scientist F; Gaurav Mishra, Scientist F; Sanjay Kumar Shahi, Scientist E; Sita Ram Meena, Scientist E; Prabir Kumar Dash, Scientist E; Nikhil Gakkhar, Scientist D; Mukesh Kumar Meena, Section Officer; Veena Singh, former Associate Director, and other officials from MNRE for their generous cooperation and support, which were instrumental in bringing this report to fruition.

The authors would like to thank Indu Shekhar Chaturvedi, NRDC Distinguished Fellow and Visiting Professor of Practice, IIT Kanpur; Vandana Padmanabhan, Research Scientist, NRDC India; Laurie Geller, Director of Peer Reviews-Science Office, NRDC; Siddharth Arora, Associate Director, NRDC India; Arpit Sharma, CEO, Skill Council for Green Jobs (SCGJ); Karan Kothadiya, Programme Lead, CEEW; Abhishek Jain, Fellow and Director - Green Economy and Impact Innovations, CEEW; Celia García-Baños, Programme Officer, Knowledge Policy and Finance Centre, IRENA; Arslan Khalid, Independent consultant, IRENA; and Michael Renner, Head - Socioeconomics and Policy, IRENA, for their review comments. The authors would like to thank the National Solar Energy Federation of India (NSEFI), All India Solar Industry Association (AISIA), Wind Independent Power Producers Association (WIPPA), Indian Wind Power Association and the Indian Federation of Green Energy (IFGE) for their review comments and support. The authors are grateful to all companies that participated in the survey.

ABOUT NRDC

NRDC (Natural Resources Defense Council) is an international nonprofit environmental organization with more than 3 million members and online activists. Established in 1970, NRDC uses science, policy, law, and people power to confront the climate crisis, protect public health, and safeguard nature. NRDC has offices in New York City, Washington, D.C., Los Angeles, San Francisco, Chicago, Bozeman, MT, Beijing and Delhi (an office of NRDC India Pvt. Ltd). Visit us at www.nrdc.org and follow us on Instagram @nrdc_org.

NRDC Chief Communications Officer: Kristin Wilson-Palmer
NRDC Senior Policy Publications Editor: Leah Stecher
NRDC Director of Peer Review, Science Office: Laurie Geller

ABOUT CEEW

The Council on Energy, Environment and Water (CEEW)—a homegrown institution with headquarters in New Delhi—is among the world's leading climate think tanks. The Council uses data, integrated analysis, and strategic outreach to support public policy, transform markets, shape technology, and nudge behaviour. CEEW seeks to explain—and change—the use, reuse, and misuse of resources. It addresses pressing global challenges through an integrated and internationally focused approach. The Council prides itself on the independence of its high-quality research and strives to impact sustainable development at scale. In over 15 years of operation, CEEW has impacted over 400 million lives and engaged with over 20 state governments. Follow us on LinkedIn and X (formerly Twitter) for the latest updates.

Cover images: iStock
Design and Production: Sanjay Chaurasia

TABLE OF CONTENTS

प्रल्हाद जोशी
PRALHAD JOSHI
ಪ್ರಲ್ಹಾದ ಜೋಶಿ

उपभोक्ता मामले, खाद्य और सार्वजनिक वितरण तथा
नवीन और नवीकरणीय ऊर्जा मंत्री
भारत सरकार

MINISTER OF CONSUMER AFFAIRS
FOOD & PUBLIC DISTRIBUTION AND
MINISTER OF NEW & RENEWABLE ENERGY
GOVERNMENT OF INDIA

Foreword

India's clean energy transition is central to our national development vision. Under the leadership of the Hon'ble Prime Minister, Shri Narendra Modi, India has not only met its climate commitments but is redefining global benchmarks. India's global leadership on renewable energy is the result of a decade of unprecedented momentum where our renewable footprint has expanded over 3.5 times since 2014, led by an extraordinary 53-fold growth in solar power. By achieving 50% cumulative installed capacity from non-fossil fuel sources in June 2025 – five years ahead of our 2030 target, we have signaled to the world that our journey towards Viksit Bharat by 2047 is non-negotiable and anchored in the spirit of Atmanirbhar Bharat.

I appreciate the Natural Resources Defense Council (NRDC) and the Council on Energy, Environment and Water (CEEW) for bringing out this comprehensive report, "**Driving Energy Transition: Workforce, Skills and Gender in India's Renewable Energy Sector.**" This study highlights that our transition is powered not just by technology but driven by our people. India's clean energy expansion is a significant engine for employment, the journey towards achieving 500GW non-fossil capacity target and the National Green Hydrogen Mission is projected to generate 44 Lakh full time equivalent (FTE) jobs. Flagship initiatives like PM Surya Ghar: Muft Bijli Yojana and Pradhan Mantri Kisan Urja Suraksha Evam Utthan Mahabhiyan (PM KUSUM) are transforming households and farmlands into Urja Kendras, that generates significantly higher local employment than traditional utility-scale projects.

As we strengthen the domestic manufacturing ecosystem, and move towards higher value-added segments, the availability of a skilled workforce will be central to sustaining this momentum. At the same time, the full potential of our clean energy sector will only be realized when we bridge the gender gap in our workforce. Currently, women are underrepresented in the sector - interventions to increase the inclusion of women will not only strengthen the workforce but also contribute to increase in household income, enhance economic resilience of communities, and support nation-building.

The Government of India remains committed to working with all stakeholders to translate its vision of Viksit Bharat into action, and I appreciate NRDC and CEEW for this comprehensive work.

(Pralhad Joshi)

Office : 8th Floor, Atal Akshay Urja Bhawan, Opp. CGO Complex, Lodhi Road, New Delhi-110003
Tel. : 011-20849102, 20849103, Fax: 20849101, E-mail : ofcofmin-mnre@gov.in
Residence : 11, Akbar Road, New Delhi-110001, Tel.: 011-23014097, 23094098
Office of MP Dharwad : Chitaguppi Hospital Compound, Sir Siddappa Kambli Marg, Hubballi-580020 (Karnataka)
Tel. : 0836-2251055, 2258955, Email : pralhadvjoshi@gmail.com, officeofpralhadjoshiji@gmail.com

संतोष सारंगी, भा.प्र.से.
सचिव

Santosh Sarangi, IAS
Secretary

सत्यमेव जयते

भारत सरकार
नवीन और नवीकरणीय ऊर्जा मंत्रालय
Government of India
Ministry of New and Renewable Energy

FOREWORD

Over the past decade, India's energy transition has evolved from a niche segment into a central pillar of our national development strategy, driven by sustained policy support and institutional coordination. India ranks 3rd in the world with 274.69 GW of installed Renewable Energy capacity as on 31st March 2026, 3rd in solar power and 4th in wind power capacity. These milestones position us strongly to meet our updated 2035 NDC target of 60 percent non-fossil installed capacity and advance our vision of Viksit Bharat by 2047.

This report, **"Driving Energy Transition: Workforce, Skills, and Gender in India's Renewable Energy Sector,"** presents a timely and comprehensive assessment of employment generation across key renewable energy segments. Commissioned by the Ministry of New and Renewable Energy (MNRE) and undertaken by Natural Resources Defense Council (NRDC) and Council on Energy, Environment and Water (CEEW), the study highlights the scale of opportunity ahead, estimating 44 lakh full-time equivalent (FTE) jobs in the journey of achieving 500 GW of non-fossil capacity and the National Green Hydrogen Mission.

Central to this journey is our commitment to workforce development and specialized skilling. MNRE has been at the forefront of creating a future-ready workforce through flagship initiatives like the Suryamitra, Vayumitra, Jal Urja Mitra and Jaiv Urja mitra skill development programmes. By aligning vocational training with industry requirements, we are ensuring that our youth are not just participants but leaders in the global green economy.

The study underscores the need to enhance women's participation across the value chain. Moving beyond the current participation of 11 percent of women in the total workforce across solar and wind deployment and manufacturing sectors, it is necessary to build a more inclusive and resilient clean energy workforce.

I congratulate NRDC and CEEW teams for supporting MNRE in this joint effort. I am confident that the insights and recommendations presented in this report will serve as a valuable guide for policymakers and industry, and contribute meaningfully to building a skilled, inclusive and future-ready workforce to power India's clean energy transition.

(Santosh Sarangi)

अटल अक्षय ऊर्जा भवन, गेट नं 2 के सामने, सी.जी.ओ. काम्प्लैक्स, लोदी रोड, नई दिल्ली–110003
Atal Akshay Urja Bhawan, Opp. Gate No. 2, CGO Complex, Lodhi Road, New Delhi-110003
Tel. : 011-20849010, 20849011 • E-mail : secy-mnre@nic.in
website : www.mnre.gov.in

LIST OF FIGURES

LIST OF TABLES

LIST OF ABBREVIATIONS

AI	Artificial Intelligence
ALMM	Approved List of Models and Manufacturers
CBG	Compressed Biogas
CEEW	Council on Energy, Environment and Water
COP	Conference of the Parties to the United Nations Framework Convention on Climate Change
CSR	Corporate Social Responsibility
DPR	Detailed Project Report
DRE	Decentralized Renewable Energy
EPC	Engineering, Procurement, & Construction
FSPV	Floating Solar Photovoltaic
FTE	Full-Time Equivalent
FY	Financial Year
GDP	Gross Domestic Product
GW	Gigawatt
HP	Horse Power
HRMS	Human Resource Management System
IoT	Internet of Things
IRENA	International Renewable Energy Agency
ITI	Industrial Training Institute
kW	kilowatt
LED	Light Emitting Diode
MBA	Master of Business Administration
ML	Machine Learning
MMT	Million Metric Ton
MNRE	Ministry of New and Renewable Energy, Government of India
MW	Megawatt
NISE	National Institute of Solar Energy

NRDC	Natural Resources Defense Council
NSDC	National Skill Development Corporation
NSQF	National Skills Qualification Framework
O&M	Operations and Maintenance
PM-KUSUM	Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan
PV	Photovoltaic
RE	Renewable Energy
SAP	Systems, Applications & Products in Data Processing
SCADA	Supervisory Control and Data Acquisition
SCGJ	Skill Council for Green Jobs
SECI	Solar Energy Corporation of India Limited
SHG	Self Help Group
SHP	Small Hydro Power
STEM	Science, Technology, Engineering, and Mathematics
TPD	Tons Per Day
TPH	Tons Per Hour
USEER	United States Energy & Employment Report

EXECUTIVE SUMMARY

India is making significant progress in pursuing and achieving its energy transition goals. The country now ranks third globally in renewable energy installed capacity.[1] India also achieved its target of meeting 50 percent of cumulative electric power installed capacity from non-fossil sources in 2025, five years ahead of schedule.[2] Clean energy technologies play a critical role in India's vision of a Viksit Bharat (an economically developed, self-reliant, and prosperous India) by 2047 and achieving net-zero emissions by 2070.

An accurate estimation of clean energy jobs, skill requirements, and gender participation aids in informing skill-building programs, developing measures to ensure a gender and equity-focused energy transition, and helping policymakers develop programs to optimize job creation, among other benefits. To this end, with support from the Government of India's Ministry of New and Renewable Energy, the Natural Resources Defense Council (NRDC) India and the Council on Energy, Environment and Water (CEEW) conducted a primary survey of companies in 2024-25 across the solar, wind, bioenergy, and hydropower sectors to assess the clean energy workforce advancements in India.

The study has developed full-time equivalent (FTE) coefficients for assessing the workforce intensity across business phases (these phases include business development, pre-construction, construction, operation and maintenance, etc. Details in Table 2). The FTE coefficient or job-year is a ratio of the time spent by an employee on a particular project or task in a given year to the standard total working hours in that particular year. These FTEs are standardized per megawatt (MW) or as per the standard unit of measurement in the sector.[i] The study also examines trends in representation of women in the clean energy workforce, skill requirements and new clean energy workforce additions between financial year (FY) 2023 and 2026.

Key Findings

- The FTEs developed across the clean energy sectors are mentioned in Table ES1. The following are some of the key employment insights from the various sectors:
    - Deployment in decentralized systems generates more jobs than large-scale systems. For example, rooftop solar systems generate 44 times more FTE (job-years)/MW than utility-scale solar systems.
    - Among the electricity generating sectors, biomass to power has the highest FTE at 164.82 FTE (job-years)/MW with the collection of feedstock phase being the most labor intensive (35 percent of the total FTE). In the case of small hydropower, which has the next highest coefficient of 152.43 FTE (job-years)/MW, the construction and commissioning phase is the most labor intensive (86 percent of the FTE).
    - In the previous four financial years (FY23 to FY26), approximately 6.5 lakh (657,845) workers have been added to the total workforce in the clean energy sectors of ground-mounted solar, rooftop solar, biomass to power, wind, small hydropower, large hydropower, and under the Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM) scheme (Figure ES1). The majority (62 percent) of the workforce addition was driven by the rooftop solar sector.

---

i Jobs created are different from the workforce added. A single worker can hold multiple short-term jobs across the years, which means that total jobs created will always exceed the workforce employed. For example, workers trained for earlier capacity additions continue contributing to new deployments, so only the incremental new workers required constitute additional workforce. This report estimates both the additional workforce added in the past four years and the total jobs generated in meeting India's 500-gigawatt (GW) target by 2030.

Table ES1: Sector-wise FTE Employment Coefficients

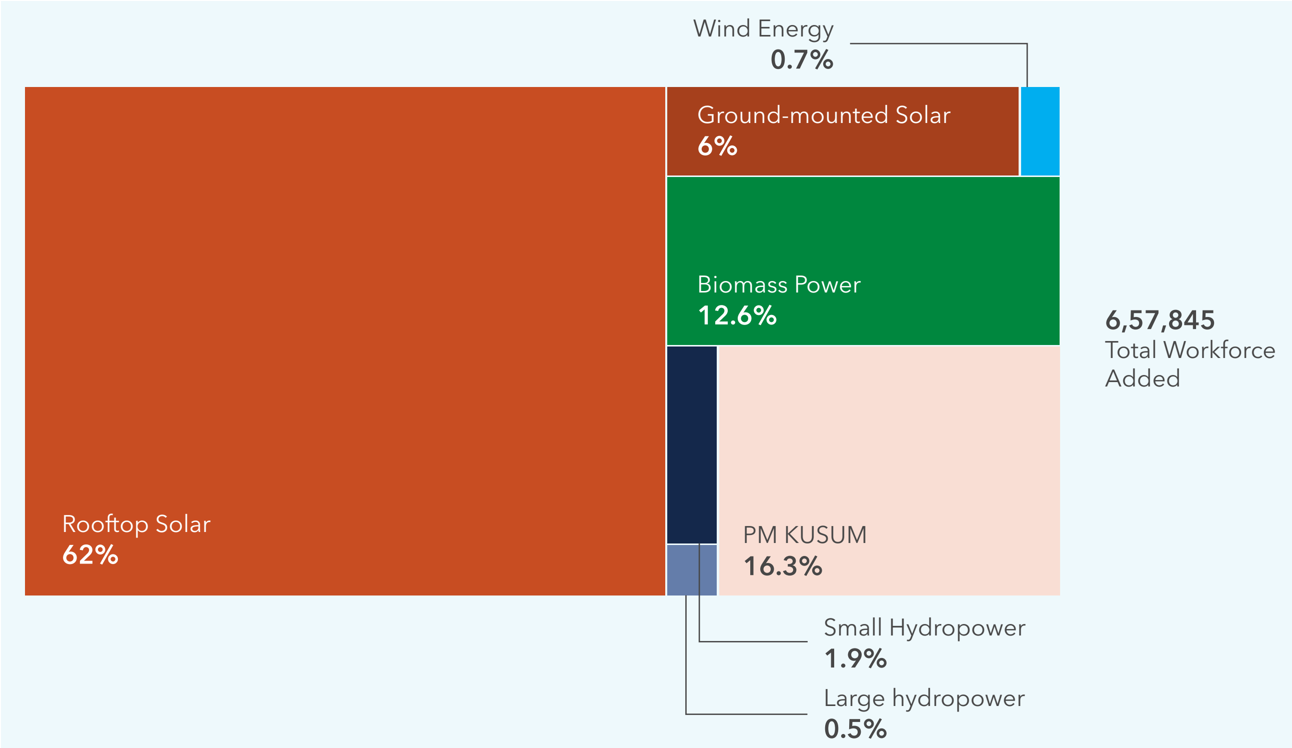
Sector	Coefficient	Unit
Deployment Sectors		
Ground-mounted Solar	1.00	FTE (job-years)/MW
Rooftop Solar	44.68[ii]	FTE (job-years)/MW
Floating Solar	2.21	FTE (job-years)/MW
Wind	0.65	FTE (job-years)/MW
Small Hydropower	152.43	FTE (job-years)/MW
Biomass to Power	164.82	FTE (job-years)/MW
Compressed Biogas (CBG)	9.91	FTE (job-years)/TPD
PM-KUSUM Component A*	1.17	FTE (job-years)/MW
PM-KUSUM Component B**	47.91	FTE (job-years)/MW
PM-KUSUM Component C Grid-connected Pumps (IPS)***	47.32	FTE (job-years)/MW
PM-KUSUM Component C Feeder-level Solarisation (FLS)****	1.17	FTE (job-years)/MW
Large Hydropower*****	0.72	FTE (job-years)/MW
Manufacturing Sectors		
Solar Module Manufacturing	1.51	FTE (job-years)/MW
Solar Pumps manufacturing	6.37	FTE (job-years)/MW
Wind Manufacturing	1.44	FTE (job-years)/MW
Pellet Manufacturing	8.04	FTE (job-years)/TPH

Notes:
** Ground-mounted solar FTE (for smaller systems below 2 to 3 MW) used here, as the scheme targets smaller sized systems.*
*** Rooftop solar FTE for 5-kilowatt (kW) systems, along with solar pumps systems installation FTE, have been used in this case.*
**** Rooftop solar FTE for 5 kW systems have been used.*
***** Ground-mounted solar FTE (for smaller systems below 2 to 3 MW) used for feeder-level solarisation.*
****** FTE for O&M phase only*

Source: CEEW-NRDC Analysis, 2026

ii While rooftop solar generates 44.68 FTE (job-years)/MW, smaller system sizes under 10 kW generate 54.91 FTE (job-years)/MW. The FTE for 1 to 10 kW is used to estimate the jobs generated under the government's 40 GW target, as the additional 30 GW to be deployed after 2024 is targeted towards the residential sector under the PM Surya Ghar: Muft Bijli Yojana.

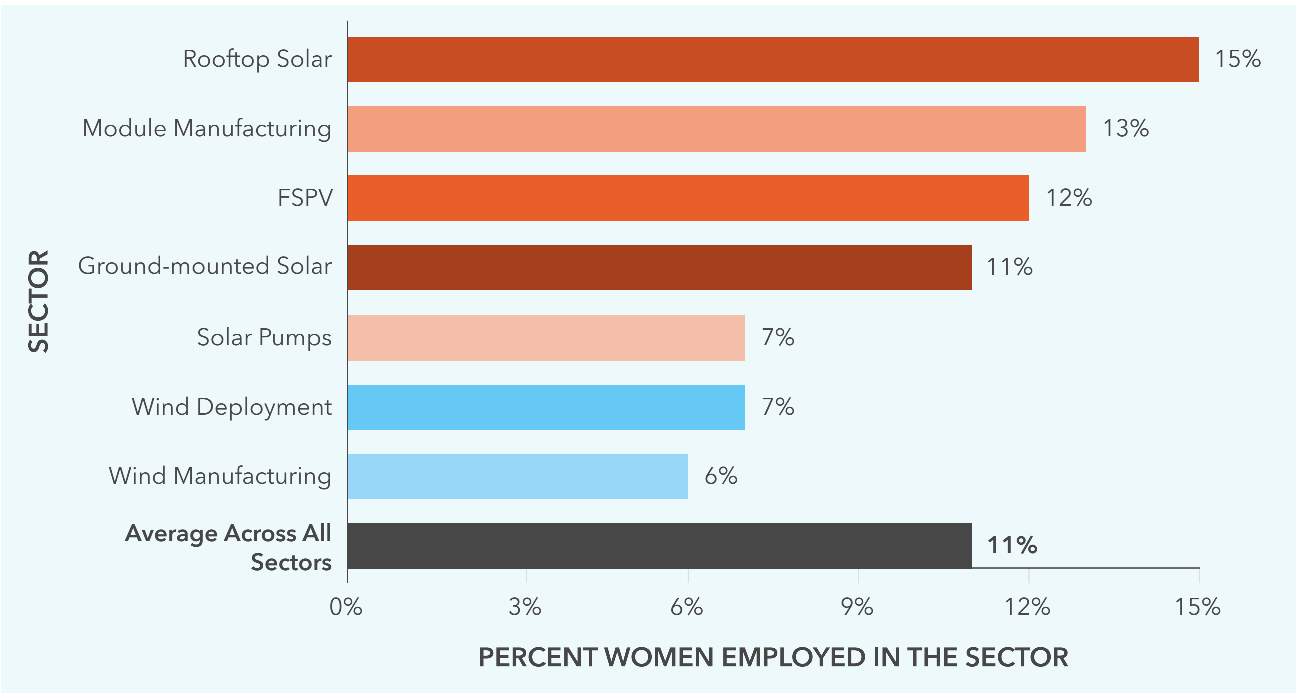
Figure ES1: 6.5 lakh workforce were added in India's clean energy sectors between FY23 and FY26



Source: CEEW-NRDC Analysis, 2026

- Women represent only 11 percent of the total workforce in the solar and wind deployment and manufacturing sectors. About 62 percent of the total women in the workforce are employed in non-technological roles such as HR, accounting, and administrative. Meanwhile, approximately 44 percent of the companies in the study sample had at least one woman board member.

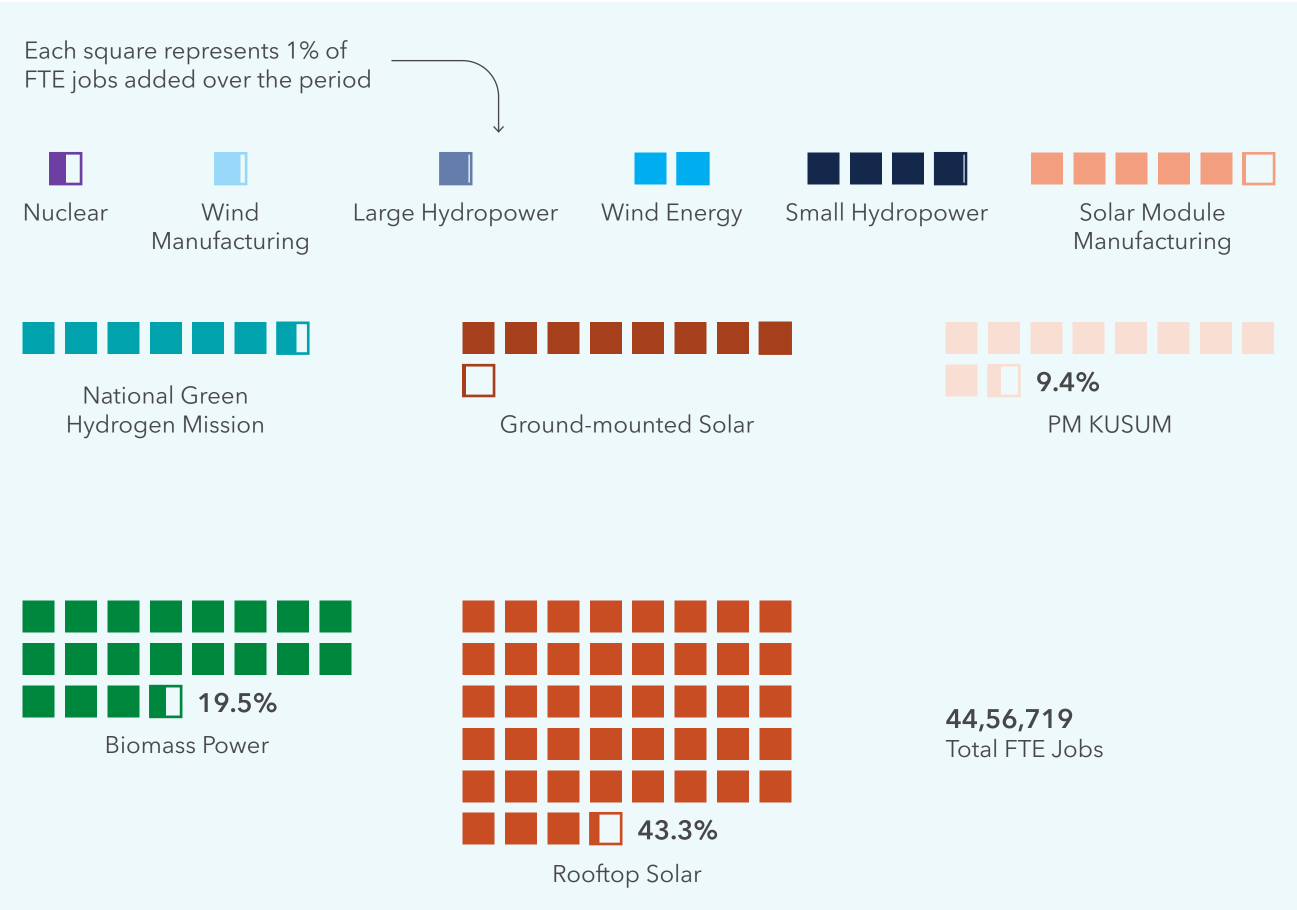
Figure ES2: Women represent 11 percent of the total workforce engaged in deployment and manufacturing of solar and wind technologies



Source: CEEW-NRDC Analysis, 2026

- Approximately 60 percent of the jobs in clean energy project deployment require highly-skilled or semi-skilled workforce. The figure is higher in the case of manufacturing sectors, with about 80 to 90 percent of the workforce engaged in highly-skilled or semi-skilled jobs.
- India meeting its 500 GW non-fossil capacity target and achieving other goals under the National Green Hydrogen Mission is estimated to generate over 44 lakh (4.4 million) FTE jobs.[iii] Approximately 12.8 lakh (1.28 million) of the total FTE jobs estimated to be generated across the solar, wind, bioenergy, hydropower, and solar pumps sectors in achieving these targets, are expected to be in the operations and maintenance and manufacturing roles—sustained over the lifetime of each project or manufacturing facility.

Figure ES3: Over 44 Lakh Full-time Equivalent Jobs can be Generated from Achieving India's 500 GW Non-fossil Fuel target and the National Green Hydrogen Mission.



Source: CEEW-NRDC Analysis, 2026 and Ministry of New and Renewable Energy, 2024

Based on this analysis, the report proposes the following recommendations to strengthen evidence-based decision making on jobs and skills, and build a robust clean energy jobs ecosystem:

1. **The Ministry of New and Renewable Energy can institutionalize mandatory reporting of renewable energy workforce to collect timely data:** By integrating workforce reporting requirements with existing government data collection mechanisms—such as in subsidy disbursement processes, tenders, and other regulatory frameworks administered by MNRE, Solar Energy Corporation of India, and the National Institute of Solar Energy—comprehensive data on workforce trends can be easily collected without additional cost or effort.

iii This report has not developed FTE coefficients for green hydrogen and nuclear energy sectors. The numbers of jobs and targets have been taken from the Ministry of New and Renewable Energy's report, "Opportunities in the Green Economy: Skilling and Jobs in Renewable Energy", published for the Fourth National Conference of Chief Secretaries, 13-15 December 2024.

2. **Clean energy companies should undertake initiatives towards gender inclusivity to tap into underutilized talent:** This can be done by ensuring workplace safety provisions, allowing for flexible work conditions and initiatives to increase women's participation in technological roles and in leadership positions.
3. **Clean energy companies should create opportunities for employee career advancement, given that an increasing proportion of jobs require higher skills in the solar and wind sectors:** Since a growing proportion of jobs in the solar and wind sectors require a highly- or semi-skilled workforce, clean energy companies and training institutes should develop career advancement programs that enable workforce progression from low- to semi-skilled and semi- to high-skilled roles through continuous learning, expert partnerships, and long-term mentorship.

1. INTRODUCTION

The global energy landscape is undergoing a rapid transformation. The energy sector continues to scale at an unprecedented pace driven by growing populations, expanding economies, and rapid technological advancements. Simultaneously, the urgency of the climate crisis is compelling nations worldwide to accelerate their decarbonization efforts and transition towards cleaner, more sustainable energy systems. At COP27, countries like Canada, Japan, Korea, and the United Kingdom reaffirmed their commitment to achieve their set targets for net-zero emissions. The following year, at COP28, 133 countries came together to deliver the 'UAE Consensus' where these countries committed to increasing the globally installed renewable capacity threefold by 2030. At the COP30 held in 2025, while there was no explicit reference to phasing out fossil fuels, key positive highlights included strategies to accelerate the implementation of the Paris Agreement, a push to triple adaptation finance, and commitments toward a just energy transition.[3] The energy transition is both a climate imperative and an economic opportunity. In July 2025, India achieved its Nationally Determined Contribution of meeting 50 percent of its cumulative electric power installed capacity from non-fossil fuel sources five years ahead of the 2030 target, thus reinforcing the nation's vision to decarbonize while developing. Energy security and indigenization are critical to achieve the aim of a Viksit Bharat by 2047. Consequently, renewable energy deployment and manufacturing are essential priorities for India's sustainable development trajectory.

With an estimated total solar and wind energy potential of 22,060 GW in the country, the sector is poised for appreciable growth in the coming years.[4] Achieving this potential will not only create new employment opportunities but will also demand an unprecedented scale of workforce skill building, reskilling, and upskilling to meet the evolving needs of the sector.

What is the Need for Estimating Renewable Energy Jobs?

As renewable energy technologies evolve rapidly—ranging from solar photovoltaics and wind turbines to battery storage, green hydrogen, and smart grids—India's energy ecosystem is becoming increasingly sophisticated. The growth of these technologies is driving the expansion of entire value chains, from manufacturing and infrastructure development to operations, maintenance, and service industries. Allied sectors like power electronics, materials, critical minerals, transport, and digital and financial services are now deeply interconnected with the clean energy space, thus amplifying both job creation potential and economic opportunities. In this light, estimating clean energy jobs becomes essential. Detailed information on job opportunities across sectors, skill distribution, requirements across job roles, and gender participation, can aid:

- **Policymakers in designing appropriate measures to support the growth of sectors with high employment potential:** The intensity of labor requirements differs across sectors and geographies (urban/rural). Policymakers can support the unlocking of clean energy technologies that have a high employment potential.
- **Inform the design and implementation of skill development and training programs:** Based on global projections, as of August 2022, approximately 140 lakh (14 million) new clean energy jobs could be created, with an additional 160 lakh (16 million) workers expected to transition into new clean energy roles by 2030.[5] Such workforce data is vital for a country like India, which is home to one of the largest labor forces in the world (with almost 500 million people in the labor

force as of 2020) and pursuing ambitious renewable energy goals.[6] It can help guide investments in education, training, and ecosystem development, ensuring that the workforce keeps pace with technological changes, thus maximizing the social and economic benefits of the transition. Robust clean jobs data can help policymakers and industry leaders anticipate future workforce needs. It can also inform strategies for targeted skill building and reskilling programs, thus ensuring that the labor resource needs of this fast-changing sector are adequately met.

- **Enable a gender-balanced and equitable energy transition:** Women remain underrepresented in the workforce both in India and globally. Gender inclusion is not just an equity issue—it drives innovation, strengthens sustainability, and ensures a just transition for all. Achieving this begins with accurately analysing the current representation trends of women in the workforce and leadership.

2. OBJECTIVES OF THE STUDY

The objectives of this study are to:

- Analyse the quantum of workforce employed in the clean energy industry in India.
- Quantify the labor intensities across various roles within each technology segment.
- Assess the participation of women in the clean energy workforce.
- Examine the skills levels of various clean energy sector jobs.

Together, these objectives provide a comprehensive baseline of India's clean energy workforce, thereby informing the steps needed to scale capacity, strengthen skills, and advance inclusion as the sector expands.

Image source: iStock

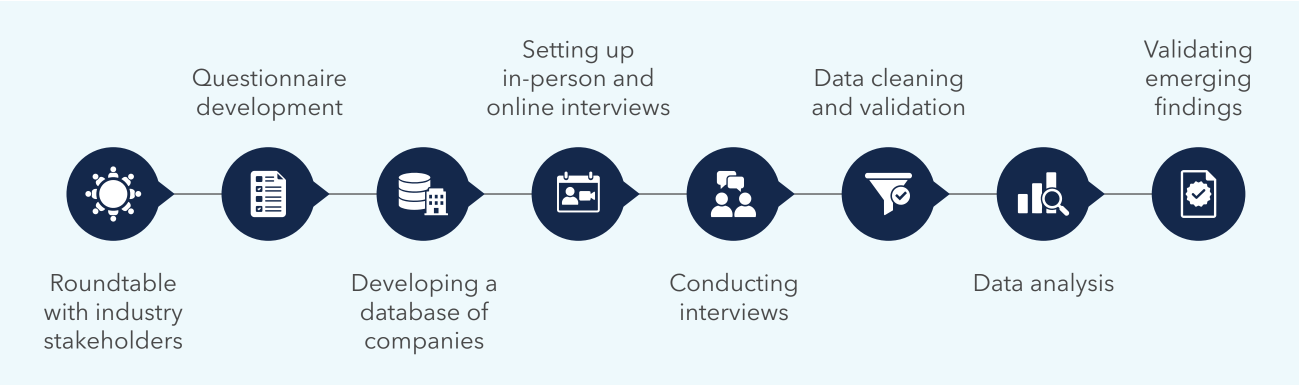
3. METHODOLOGY

This section expands on the methodology and data analysis used in this study. A comparison of the current study with four other studies available globally is provided in Annexure 1. The methodologies used in these studies are reviewed and compared across several parameters including geographical coverage of the study, scope of the jobs examined, sectors included in the study, types of jobs assessed (direct, indirect or induced), sources of data, survey, and job estimation techniques.

This study estimates the direct jobs[iv] created during the component manufacturing, deployment, and operation stages in the solar (ground-mounted, floating, rooftop, mini-grids, streetlight, modules manufacturing, solar pump manufacturing), wind (on-shore), bioenergy (compressed biogas (CBG), biomass to power, biogas[v], pellet and biodigester manufacturing), and small and large hydropower (deployment and turbine manufacturing) sectors. The direct jobs are estimated using the full-time equivalent (FTE) coefficient methodology, which allows standardization and comparison of jobs of varying duration by converting them to full-time equivalent jobs.[7]

The FTE coefficients have been developed based on a primary survey of companies engaged across various clean energy sectors. Structured questionnaires were used to collate information on assessing different aspects of jobs in the clean energy sectors, and this information was then used to develop the corresponding employment coefficients. The first set of questions focused on company-wide details such as total workforce employed, participation of women in the workforce, capacity management, investments in automation, among others. The second set of questions focused on understanding project-level information on workforce needed, time taken, and skill profile of the workers at each stage. The surveyed companies were requested to share these details for any recently commissioned project. Due to a low number of responses from the bioenergy sectors, the questionnaire was strategically shortened to concentrate on employment and capacity data, thereby improving participant response rates. Annexure 2 shows the sample questionnaire for biomass to power developers.

Figure 1: Process Followed to Develop the Full-time Equivalent Employment Coefficients



iv Jobs created are different from the workforce added. A single worker can hold multiple short-term jobs across the years, i.e., total jobs created will always exceed the workforce employed. For example, workers trained for earlier capacity additions continue contributing to new deployments, so only the incremental new workers required constitute additional workforce. This report estimates both the additional workforce added in the past four years and the total jobs generated in meeting India's 500 GW target.

v This includes biogas flexi model, plants of approximately 2 cubic meters designed for household use.

Table 1 shows the scope of the primary survey of companies in the focused clean energy sectors. More than 1,200 companies were identified based on the market research reports. It is to be noted that while there are 51 generating companies, including private, central government-level, and state government-level entities, in the large hydropower sector, not all of these companies were approached for the study. As only state or central-level companies that had commissioned a project in the last 10 years were considered for the purpose of the study, this reduced the target population size to nine.[8 9 10]

Project developers, engineering, procurement and construction (EPC) firms, vendors, and manufacturers across all the identified sectors were contacted for the data collection survey.

Table 1: Number of Companies Targeted for the Primary Survey to Develop the FTE Coefficients

Clean Energy Technology or Sector	Sub-sectors	Total Number of Companies Identified for the Survey	Total Number of Companies Approached for the Survey
Solar Project Deployment	Ground-mounted Solar	104	104
	Rooftop Solar*	222	222
	Floating Solar	18	18
	Mini-grid	26	26
	Solar Water Pump**	57	57
	Solar Streetlight**	24	24
Solar Component Manufacturing	Solar Cell	22	22
	Solar Module	82	82
	Solar Inverter	40	40
	Mounting Structure	41	41
Wind Project Deployment	Wind	99	99
Wind Component Manufacturing	Manufacturers of Components such as Blade, Nacelle, Tower, Control Boxes	40	40
Bioenergy Project Deployment	Biomass to Power	53	53
	Supply Chain Operators	25	25
	Biogas	15	15
	Pellet Manufacturing	25	25
	CBG	81	81

Clean Energy Technology or Sector	Sub-sectors	Total Number of Companies Identified for the Survey	Total Number of Companies Approached for the Survey
Bioenergy Component Manufacturing	Biodigester Manufacturing	7	5
Hydropower Project Deployment	Small Hydropower	120	120
	Large Hydropower	51	9
Total		**1,064**	**1,022**

Note:
** Rooftop Solar covers companies and projects for commercial, industrial, and residential installations.*
*** While there are multiple decentralized clean energy technologies, such as solar sewing machines, solar dryers, biomass-based cold storage, etc., the survey focused on solar water pumps and solar streetlights as they have the highest number of deployments (above 20,000 units deployed) and dedicated government support to accelerate deployment.*

Source: CEEW-NRDC Analysis, 2026

Within the solar sector, we focus on deployment of workforce in the ground-mounted solar (such as solar parks and open access projects), rooftop solar, and floating solar sectors, along with decentralised systems that include solar pumps and solar streetlights. Manufacturing covers solar cell and module manufacturing, as well as the balance of system components such as inverters and mounting structures. The wind sector covers onshore wind project deployment and the manufacturing of blades, nacelles, towers, and control boxes. In the bioenergy sector, the focus is on the deployment of the biomass to power and bio-CNG production plants, along with the manufacturing of biodigesters. Hydropower technology includes the deployment of workforce in both small and large projects, and components such as turbines, generators, valves, penstock, control systems, gates, pumps, and others.

This study focuses on direct jobs, which refer to those generated during deployment or in manufacturing activities. However, clean energy jobs can also be indirect and induced. While indirect jobs include financing of projects, insurance, ancillary industries, etc., induced jobs include jobs funded from the earnings of employees, such as services (restaurants, hotels, etc.) arising in the area of deployment. This study does not estimate indirect or induced jobs.

Another important aspect to consider when estimating clean energy jobs is the duration of the jobs created: short-term or long-term. For instance, the construction jobs in developing a clean energy project will be short-term, lasting only until the construction continues. These are one-time jobs, whereafter, the workers are absorbed into new projects. Meanwhile, jobs under the operation and maintenance (O&M) phase continue for the lifetime of the plant, which can range from 25 to 30 years in the case of larger-scale wind and ground-mounted solar sectors to longer for the hydropower sector. On the other hand, all activities in the manufacturing sector are considered to be 'long-term' as they will be required for as long as the production continues. This report focuses on both the short-term and long-term types of jobs.

Table 2 shows the key activities considered for project deployment and manufacturing across various technologies. The FTE coefficients have been developed for each of these activities for all sectors. Large hydropower sector is the only exception, where the FTE has been developed only for the O&M phase as the hydropower companies contacted during the survey did not maintain reliable data for the initial phases (business development, design and pre-construction, and construction and commissioning).[vi]

vi Based on primary consultations with hydropower companies and other stakeholders in the sector. The lack of reliable data is due to the longer duration (around 10 to 12 years) of developing a large hydropower system and the contractual nature of work leading to gaps in available data.

Definition of business phases:

- Business development: This phase refers to the pre-development phase and involves activities like estimations, pricing, budget, land, government liaison, etc.
- Pre-construction: This phase refers to designing a project and other pre-construction activities.
- Construction: This phase refers to field activities like site preparation, construction, installation, and grid integration.
- Operation and Maintenance (O&M): This phase refers to the operation and maintenance of the project.

Table 2: Individual Phases Considered, Across Technologies, to Develop Corresponding FTE Coefficients

Technology	Sub-sector	Activities Covered
Solar	Deployment: Ground-mounted, Rooftop, Floating, Mini-grids	Business Development, Design and Pre-construction, Construction and Commissioning, O&M
	Manufacturing: Module, Cell, Inverters, Mounting structures	Procurement, Design, Production, Business Development, Corporate Functions (such as finance, legal, HR)
Decentralised Renewable Energy Applications	Solar Street Lights	Solar Streetlight Manufacturing, Controller Manufacturing, System Integration
	Solar Water Pumps	Pump manufacturing, Controller manufacturing, System integration
Wind	Deployment: Wind (onshore)	Business Development, Design and Pre-construction, Construction and Commissioning, O&M
	Manufacturing: Nacelle, Tower, Blade, Hub and Control Box Manufacturing	Procurement, Design, Production, Corporate Functions (finance, legal, HR)
Bioenergy	Deployment: Biomass to Power, CBG	Business Development, Design and Pre-construction, Construction and Commissioning, O&M
	Biogas	Business Development, Installation, O&M
	Pellet Manufacturing	Business Development, Collection of Feedstock, O&M
	Biodigester Manufacturing	Procurement, Design, Production, Business development, Corporate Functions (finance, legal, HR)
Hydropower	Deployment: Small Hydropower	Business Development, Design and Pre-construction, Construction and Commissioning, O&M
	Deployment: Large Hydropower	O&M[vii]

Source: CEEW-NRDC Analysis, 2026

The skill requirements vary across the clean energy sectors and across the activities under different phases listed in Table 2. This study identifies these skill sets and classifies the skilled workforce under three categories: low-, semi-, and highly-skilled. These are defined and mapped as per the National Skills Qualifications Framework (NSQF) levels as discussed below.[11]

vii Based on primary consultation with companies, the typical duration of developing a large hydropower system is about 10 to 12 years. It changes further depending on the project and location. Many companies contacted did not maintain reliable data for these initial phases. Hence, the scope is limited to operation and maintenance.

- **Low-skilled:** These are roles where no formal education is required. The individual carries out repetitive work and is familiar with common trade terminologies. This category corresponds to NSQF level 1 to 2.
- **Semi-skilled:** These are roles where technical qualification or vocational skills are required. The individual has limited responsibility for select tasks with limited problem-solving skills. This category corresponds to NSQF level 2.5 to 5.5.
- **Highly-skilled:** These are roles that require engineering or advanced degrees. The individual has the responsibility of executing various deliverables and possesses knowledge of organisation strategy, practical or specialised areas as required. This category corresponds to NSQF level 6 and above.

3.1 Data Collection

An external survey agency was brought on board to conduct the primary survey, which collected data using structured questionnaires via in-person, telephonic, and online interviews. Each sub-sector mentioned in Table 1 had a separate questionnaire that allowed the development of sector-specific FTE coefficients. The questionnaires carried questions to identify the manufacturing or power generation capacity, the number of people employed across different business phases or departments, and the duration of these business phases in order to calculate the specific FTE coefficients. Respondents were asked to provide details for one recently completed project. The number and size of projects covered across different sectors are provided in Annexure 3. Large projects, in general, are thought to have a greater workforce efficiency as compared to smaller ones. Therefore, a mix of small, medium, and large projects was considered for this study to ensure that efficiencies across all project sizes are captured.

The survey questionnaire also covered the theme of gender with questions on representation of women in leadership roles (corporate roles and company board memberships), participation of women across activities and business phases, and special initiatives to increase participation of women.[viii] The survey further included questions related to skills—specific skill requirements in the sector, difficulties in finding workforce with specific skill sets, and the impact of automation on jobs. Annexure 2 shows the questionnaire for biomass to power deployment.

Data was collected from current employees in companies spanning different departments such as human resources, management, and project teams. The interviews with stakeholders were conducted in-person, telephonically, and virtually. One of the limitations of the survey exercise was that many companies in the population were no longer in operation at the time of this survey and therefore could not be contacted. Further, access to contact details for relevant officials from the departments mentioned above was not always possible. As a result, **only about 750 companies out of the more than 1,000 companies targeted for the survey across sectors could be contacted for this study through email, phone, or in-person visits.**

Several factors impacted the responses to the survey, including concerns around data confidentiality and cross-team collaboration. For many organizations, disclosing employment and other sensitive information posed a significant data privacy concern, which prevented them from providing the requested information. Other reasons for the organizations' inability to provide the requested information may have included low priority to participate in the jobs assessment study, human resources constraints, and lack of data sharing mandates. Moreover, the questionnaire's requirement for cross-departmental data collection, combined with respondents' time constraints due to conflicting priorities, resulted in many incomplete responses. As a result, the authors received **fully completed responses from 529 companies.**

viii Presence of women on the company's board was a Yes/ No (binary) question. Thus, while data was received on whether companies have women on their boards, data was not collected on the number or proportion of women on company boards.

3.2 Data Cleaning and Validation

The data cleaning and validation process consisted of three steps: digitizing the data, data quality assessment (which included outlier analysis for sectors with high sample sizes), and validation.

Several issues were identified during data quality assessment. In the deployment sectors, delays in the project were included in the total duration by the companies. Additionally, it was unclear whether missing data in certain phases represented unreported information or reflected the limited scope of the companies' business activities.

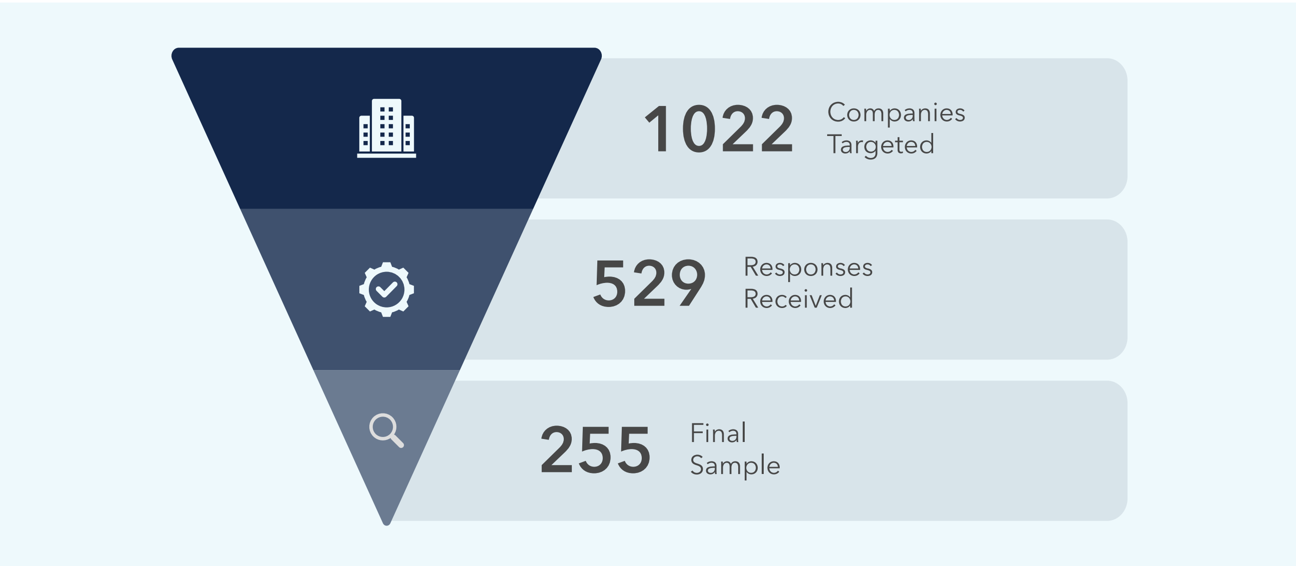
In the manufacturing sectors, it was observed that companies were often engaged in manufacturing multiple products. For instance, in wind manufacturing, companies often have overlapping teams working across multiple components. Thus, in the cases where respondents were unable to provide separate data on employee time allocation for each component, such responses were excluded from the sample.

For the ground-mounted solar, rooftop solar, and wind deployment sectors, outliers were detected using Z-scores. Outlier analysis was conducted for these sectors due to the availability of a large sample to conduct such an analysis. After identifying outliers (standard deviation of three and above) and other data points that may need validation, validation calls were made to back-check the data. For the other sectors, at least 30 percent of the sample was validated. Meanwhile, for sectors with a sample size below five companies, 100 percent of the sample was validated.

Validation calls were made to ensure that data for key variables such as project size, workers in each phase or department, and duration of each phase was correct. In some cases, different team members of the same project or facility were contacted to verify the data. Responses with outliers or other data quality issues that could not be validated were dropped.

After undergoing a rigorous data cleaning and validation process, **255 responses out of the 529 received responses** were included in the final sample.

Figure 2: Process of Finalizing Sample Group from Received Responses for FTE Employment Coefficient Development



Source: CEEW-NRDC Analysis, 2026

Table 3: Sector-wise Break Down of Sample Sizes Used to Develop FTE Employment Coefficients and Case Studies

Technology	Number of Companies from which Responses were Collected	Number of Companies in the Final Study Sample After Data Cleaning and Validation	Total Market Size of the Companies in the Sample (based on installed RE capacity, per RE Navigator 2024)	States and UTs Covered (Project Locations in Case of Deployment)
Ground-mounted Solar	46	19	27%	Rajasthan, Karnataka, Gujarat, Madhya Pradesh, Maharashtra, Telangana, Uttar Pradesh
Mini-grid*	5	2	-	Maharashtra
Rooftop Solar	273	135	18%	Andhra Pradesh, Assam, Bihar, Chhattisgarh, New Delhi, Gujarat, Haryana, Himachal Pradesh, Jammu & Kashmir, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Telangana, Uttar Pradesh, Uttarakhand, West Bengal, Andaman and Nicobar Islands, and Chandigarh
Floating Solar	3	3	Not available (NA)	Telangana, Jharkhand, Punjab
Solar Water Pumps (only pumps manufacturing and installation)	6	4	NA	Maharashtra, Madhya Pradesh, Uttar Pradesh, Assam
Solar Pumps (solar PV installation only)	11	0	NA	-
Solar Street Lights*	2	1	NA	Uttar Pradesh
Wind Deployment	23	19	24%	Gujarat, Karnataka, Tamil Nadu, Andhra Pradesh
Solar Module Manufacturers	19	8	16%	New Delhi, Maharashtra, Karnataka
Biomass to Power**	4	1	NA	Punjab, Haryana
CBG	20	9	NA	Rajasthan, Uttar Pradesh, Punjab, Karnataka, Gujarat
Supply Chain Operators	1	0	-	-

Technology	Number of Companies from which Responses were Collected	Number of Companies in the Final Study Sample After Data Cleaning and Validation	Total Market Size of the Companies in the Sample (based on installed RE capacity, per RE Navigator 2024)	States and UTs Covered (Project Locations in Case of Deployment)
Wind Turbine Manufacturing	7	1	28%	-
Biogas Flexi Model Deployment and Manufacturing*	27	4	NA	Gujarat, Madhya Pradesh
Pellet Manufacturers	15	6	NA	Rajasthan, Haryana, Punjab, Karnataka, Maharashtra
Small Hydropower	55	42	NA	Himachal Pradesh, Uttarakhand, Kerala, Jammu & Kashmir, Sikkim
Large Hydropower***	1	1	NA	Manipur, Himachal Pradesh, Uttarakhand, Sikkim, Ladakh, Jammu & Kashmir
Hydropower Manufacturers	1	0	-	-
Total	**529**	**255**		

Note:

Market size data was inconsistently available across our sample survey sectors. While RE Navigator provided specific market share for some companies, smaller players were frequently aggregated under an 'Other' category. Consequently, this report considers individual market share only for large-scale companies with verifiable data; smaller entities are not included in the market share specified.

** Case studies developed, however, not included in FTE analysis.*

*** While responses were received from only one company, data was collected for 10 projects.*

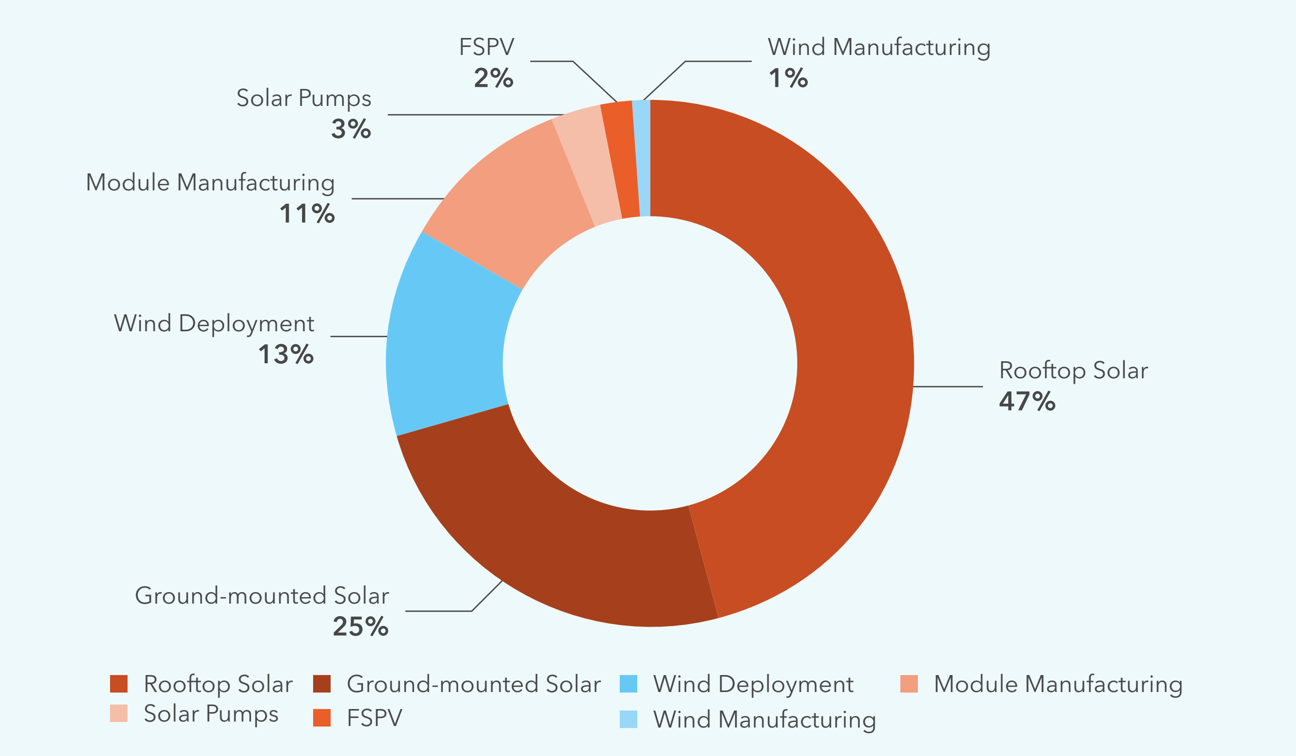
**** While responses were received from only one company, data was collected for 20 projects in the O&M phase.*

Source: CEEW-NRDC Analysis, 2026 and analysis of RE Navigator (Bridge to India) 2024

To assess the trends of representation of women in the workforce, companies were requested to share information on participation of women in the workforce at a company-wide level. This was in addition to the project-level information sought for FTE employment coefficients. It must be noted that not all companies shared data on women's participation in the workforce. Hence, **the sample size for assessing the gender representation in the renewable energy workforce is smaller than that for employment coefficients.** This study has not reported data for sectors where responses for gender participation were limited.

Following the data cleaning and validation steps, **159 companies were included in the study sample for the analysis on the representation of women in the workforce** (Figure 3), compared to the final study sample for developing FTE employment coefficients that had 255 companies. The sectors covered in the gender analysis study included rooftop solar, ground-mounted solar, wind deployment, solar module manufacturing, solar pumps, floating solar, and wind manufacturing.

Figure 3: Sector-wise Break Down of the Sample of 159 Companies Used for Gender Analysis Study



Source: CEEW-NRDC Analysis, 2026

3.3 Full-Time Equivalent (FTE) Employment Coefficients and Data Analysis

This study uses the primary responses from the survey to develop annual Full-Time Equivalent (FTE) employment coefficients (in job-years per MW or other unit depending on the renewable energy sector) for capacity deployment and manufacturing. The general approach to developing the FTE employment coefficients involves the following steps:

1. Dividing the process of capacity deployed or manufactured into different business phases.
2. Calculating the FTE (job-years) for each phase (both for deployment and manufacturing) for each company.
3. Calculating the FTE (job-years) per unit of capacity installed or manufactured for the specific phase.
4. Calculating the average FTE (job-years) per unit capacity installed or manufactured for the specific phase by including responses from all the companies included in the study.
5. Calculating the sector FTE (job-years) per unit capacity installed or manufactured by adding the average FTEs of all phases.

Step 1: Dividing the process of capacity deployed or manufactured into different phases

There are four phases for capacity development: business development, design and pre-construction, construction and commissioning, and operation and maintenance.

There are five phases for capacity manufactured: material procurement, technical (includes engineering and design), production, business development, and corporate.

Step 2: Calculating the FTE (job-years) for each phase (both for deployment and manufacturing) for each company

The calculation of the FTE for a specific phase is explained below using business development phase as an example. Calculations are done separately for deployment and manufacturing.

Deployment Sectors

FTE (job-years) is the ratio of the time taken to complete an activity to the standard working days in a year. The standard working days differ for different sectors such as agriculture, manufacturing, etc. For calculations in this report, 260 has been assumed to be the standard working days to calculate FTE (job-years) for all phases of the deployment sectors.[ix] As all phases have different durations, including the standard working days in the denominator makes them comparable to each other.

The FTE (job-year) for the business development phase for a company is therefore calculated as:

$$FTE\ (job\text{-}years)_{Business\ Development} = \frac{\begin{array}{c}\text{Total Number of Workers Needed * Percentage of Time Spent by Workers}\\ \text{on this Project * Duration of Business Development Phase (days)}\end{array}}{\text{Standard Working Days in a Year (260)}}$$

Similarly, the FTE is calculated for the other deployment sector phases, i.e., design and pre-construction, construction and commissioning, and operations and maintenance.

Manufacturing Sectors

For the manufacturing sectors, the standard working days is assumed to be 365. Since manufacturing continues all throughout the year, the time taken to complete the activity is also assumed to be 365 days.

$$FTE\ (job\text{-}years)_{Business\ Development} = \frac{\begin{array}{c}\text{Total Number of Workers Needed}\\ \text{* Duration of Business Development Phase (days) (365)}\end{array}}{\text{Standard Working Days in a Year (365)}}$$

Similarly, the FTE is calculated for the other manufacturing sector phases, i.e., material procurement, technical, production, and corporate. For solar pumps manufacturing, additional business phases of system installation and O&M are included.

Step 3: Calculating the FTE (job–years) per unit of capacity installed or manufactured for the specific phase

Deployment Sectors

The FTE per unit capacity (job-years/MW) for a specific phase is calculated by dividing the FTE (job-years) for the phase by the capacity deployed (in the relevant unit i.e. MW, tons per day, etc.).[x] The capacity unit is sector specific, and often is the standard unit in that sector. For example, the unit is MW for solar and wind deployment sectors, and tons per day (TPD) for the Biomass and CBG sectors. These units have not been made comparable to ensure usability and better interpretation of results. The following calculation is for the FTE per unit capacity for the business development phase in the solar and wind sectors (that have MW as the capacity unit).

ix This figure represents the total working days, excluding weekends, throughout the year which comes to approximately 260 days. Based on stakeholder discussions, companies generally have a five-day work week.

x MW is used as an example. The actual unit is sector dependent.

$$FTE\ (job\text{-}years/MW)_{\ Business\ Development} = \frac{FTE\ (job\text{-}years)_{\ Business\ Development}}{Capacity\ of\ the\ Project\ Deployed\ (MW)}$$

Manufacturing Sectors

The FTE per unit capacity (job-years/MW) for a specific phase in the manufacturing sector is calculated by dividing the FTE (job-years) for the phase by the capacity manufactured (in the relevant unit i.e. MW or horsepower). For solar modules and wind turbines, the capacity manufactured unit is MW, whereas for solar water pumps it is horsepower (HP). These units have not been made comparable to ensure usability and better interpretation of results. The following calculation is for the FTE per unit capacity for the business development phase for solar modules and wind turbines (that have MW as the capacity unit).

$$FTE\ (job\text{-}years/MW)_{\ Business\ Development} = \frac{FTE\ (job\text{-}years)_{\ Business\ Development}}{Capacity\ Manufactured\ Annually\ (MW)}$$

Step 4: Calculating the average FTE (job-years) per unit capacity installed or manufactured for the specific phase by taking an average of responses from all the companies included in the study

After calculating the FTEs for a phase for a particular company or project, the average FTE per unit for the specific phase for a sector is calculated by averaging the responses from all companies included in the study sample.

$$Average\ FTE\ (job\text{-}years/MW)_{\ Business\ Development} = \frac{\sum_{i=1}^{n} FTE\ (job\text{-}years/MW)_{Business\ Development\ i\ ,i=1,2,\ldots n}}{n}$$

where ‘n’ is the number of companies.

Similar approach is followed for calculating the average FTE per unit for the other phases as shown below:

$$Average\ FTE\ (job\text{-}years/MW)_{\ Design\ and\ Pre\text{-}construction} = \frac{\sum_{i=1}^{n} FTE\ (job\text{-}years/MW)_{Design\ and\ Pre\text{-}construction\ i\ ,i=1,2,\ldots n}}{n}$$

$$Average\ FTE\ (job\text{-}years/MW)_{\ Construction\ and\ Commissioning} = \frac{\sum_{i=1}^{n} FTE\ (job\text{-}years/MW)_{Construction\ and\ Commissioning\ i\ ,i=1,2,\ldots n}}{n}$$

$$Average\ FTE\ (job\text{-}years/MW)_{\ Operation\ and\ Maintenance} = \frac{\sum_{i=1}^{n} FTE\ (job\text{-}years/MW)_{Operation\ and\ Maintenance\ i\ ,i=1,2,\ldots n}}{n}$$

Similarly, the average FTE per unit is calculated for all the phases in the manufacturing sectors.

Step 5: Calculating the sector FTE (job-years) per unit capacity installed or manufactured by adding the average FTEs of all phases

Finally, the average of each phase of a sector across all companies is added to arrive at the FTE per unit for that sector. The following is the formula for the sector FTE per unit for a deployment sector:

$$\begin{aligned}\textit{Overall FTE per unit of the Sector,FTE (job-years/MW)}_{\text{Sector}} &= \textit{Average FTE (job-years/MW)}_{\text{Business Development}}\\ &+ \textit{Average FTE (job-years/MW)}_{\text{Design and Pre-construction}}\\ &+ \textit{Average FTE (job-years/MW)}_{\text{Construction and Commissioning}}\\ &+ \textit{Average FTE (job-years/MW)}_{\text{Operation and Maintenance}}\end{aligned}$$

For large hydropower sector, the FTE is computed only for the operation and maintenance phase. The formula is as follows:

$$\textit{Average FTE (job-years/MW)}_{\text{Operation and Maintenance}} = \frac{\sum_{i=1}^{n} \textit{FTE (job-years/MW)}_{\text{Operation and Maintenance } i, i=1,2,\ldots n}}{n}$$

where, ‘n’ is the number of projects.

For the manufacturing sector, the formula for the sector FTE per unit is:

$$\begin{aligned}\textit{Overall FTE per unit of the Sector, FTE (job-years/MW)}_{\text{Sector}} &= \textit{Average FTE (job-years/MW)}_{\text{Procurement}}\\ &+ \textit{Average FTE (job-years/MW)}_{\text{Technical}}\\ &+ \textit{Average FTE (job-years/MW)}_{\text{Production}}\\ &+ \textit{Average FTE (job-years/MW)}_{\text{Business Development}}\\ &+ \textit{Average FTE (job-years/MW)}_{\text{Corporate}}\end{aligned}$$

3.4 Key Assumptions of the Study

While specific assumptions have been mentioned across the methodology section, these are some of the general assumptions of the study:

1. Self-reported employment information is considered accurate: While many companies, especially smaller companies, relied on recollections rather than a well-maintained database, it was assumed that the data provided by companies is accurate. To ensure data reliability, at least 30 percent of the responses were validated and in sectors where sample sizes were 5 and below, all responses were validated.
2. Linear relationship between capacity gains and FTE employment coefficients: Annual capacities added in the sector and FTE employment coefficients are used to calculate jobs added in the last four years. It is assumed that the relationship between FTE and capacities is linear, and there are no economies of scale or technology gains as capacity increases.

4. EMPLOYMENT TRENDS IN THE CLEAN ENERGY DEPLOYMENT SECTORS

This section discusses the FTE coefficients for the deployment sectors–solar (ground-mounted, rooftop, and floating), wind, CBG, biomass to power, and large hydropower. It presents the FTE employment coefficients and the skills required for each sector based on the survey results and highlights the trends therein. Table 4 summarizes the sector FTE employment coefficients across sectors.

Table 4: Sector FTE Employment Coefficients for Deployment of Various Clean Energy Technologies

Sector	Coefficient	Unit (per year)
Ground-mounted solar	1	FTE (job-years)/MW
Rooftop Solar	44.68	FTE (job-years)/MW
PM-KUSUM Component A*	1.17	FTE (job-years)/MW
PM-KUSUM Component B**	47.91	FTE (job-years)/MW
PM-KUSUM Component C (IPS)***	47.32	FTE (job-years)/MW
PM-KUSUM Component C (FLS)*	1.17	FTE (job-years)/MW
Floating Solar	2.21	FTE (job-years)/MW
Wind	0.65	FTE (job-years)/MW
CBG	9.91	FTE (job-years)/TPD
Biomass to Power	164.82	FTE (job-years)/MW
Small Hydropower	152.43	FTE (job-years)/MW
Large Hydropower****	0.72	FTE (job-years)/MW

Notes:
** Ground-mounted solar FTE (for smaller systems below 2 to 3 MW) used as scheme targets smaller sized systems.*
*** Rooftop solar FTE for 5 kW systems, along with solar pumps systems installation FTE, have been used.*
**** Rooftop solar FTE for 5 kW systems have been used.*
***** FTE for O&M phase only*

Source: CEEW-NRDC Analysis, 2026

4.1 Solar

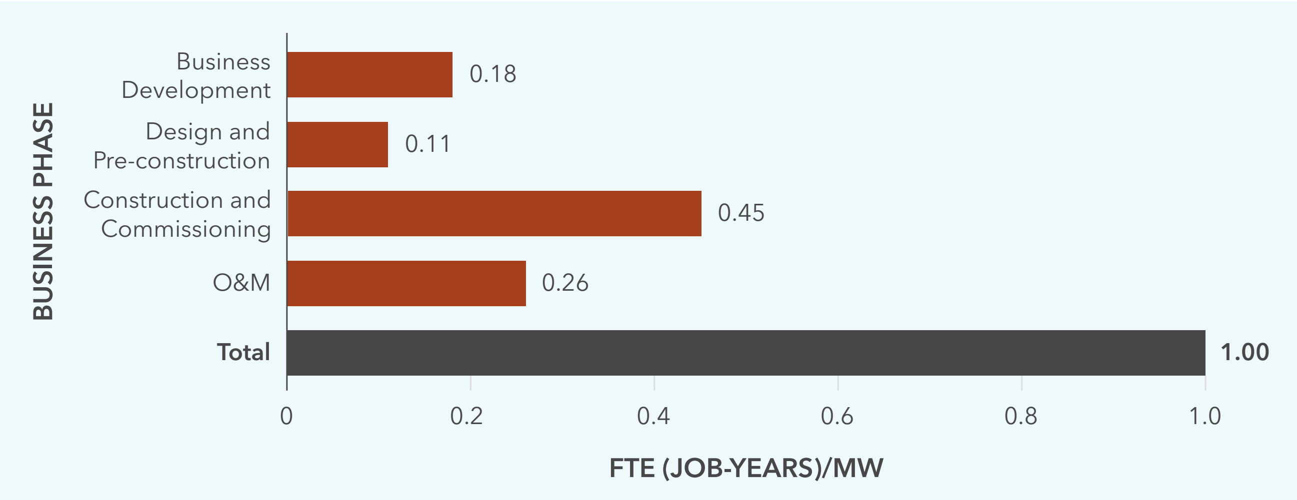
Solar is one of the leading clean energy technologies in India in terms of capacity installed. It is a geographically diverse resource that can be deployed over ground, rooftops, and water bodies. India's solar potential varies across estimates due to differences in methodology. According to MNRE and the National Institute of Solar Energy's 2025 report, India's solar potential is estimated at approximately 3343.37 GW.[12 13] Other studies, such as the research by CEEW, show that the solar potential estimate stands at 20,270 GW.[xi] [14] As of March 2026, India has a cumulative installed solar capacity stands of approximately 150 GW.[15]

Employment Coefficients

This report examines three types of solar capacity deployment: ground-mounted, rooftop, and floating solar. As explained in the previous section, employment opportunity is estimated for each project phase, which is averaged to get a sector-wide representative coefficient. Figures 4 to 6 summarize the results for three types of solar capacity deployment.

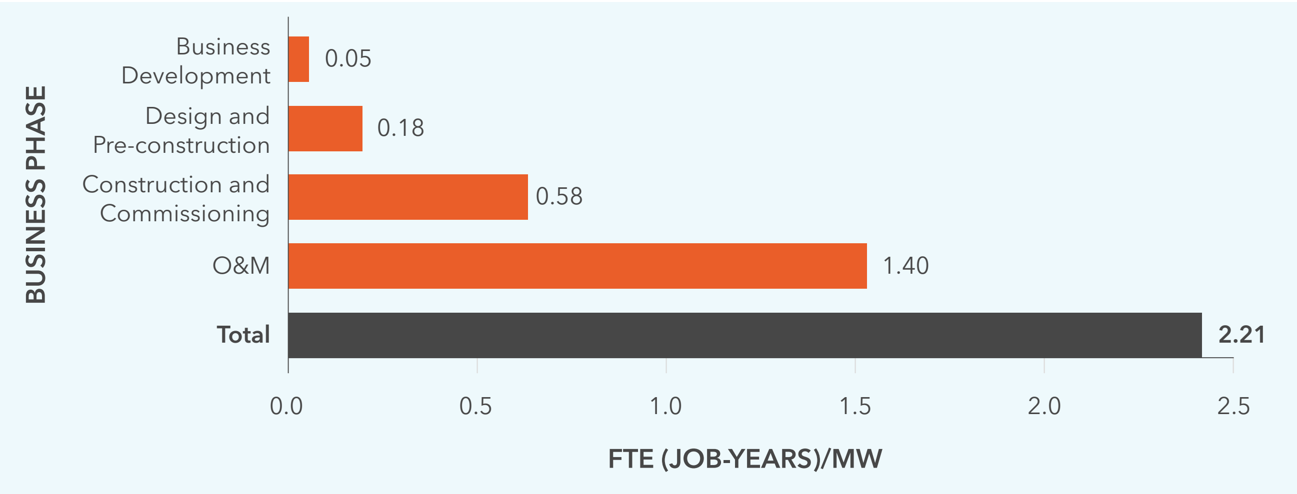
The study shows that among the three sub-sectors of solar energy, rooftop solar (44.68 FTE (job-years)/MW) generates the maximum number of jobs, on a full-time equivalent basis, followed by floating solar (2.21 FTE (job-years)/MW) and ground-mounted solar (1 FTE (job-years)/MW). The **number of jobs created by deploying one MW of rooftop solar projects per year is about 20 times more than that of a floating solar project, and 44 times more than that of a ground-mounted solar project.**

Figure 4: Phase-wise FTE Employment Coefficients for Ground-mounted Solar Sector



Source: CEEW-NRDC Analysis, 2026

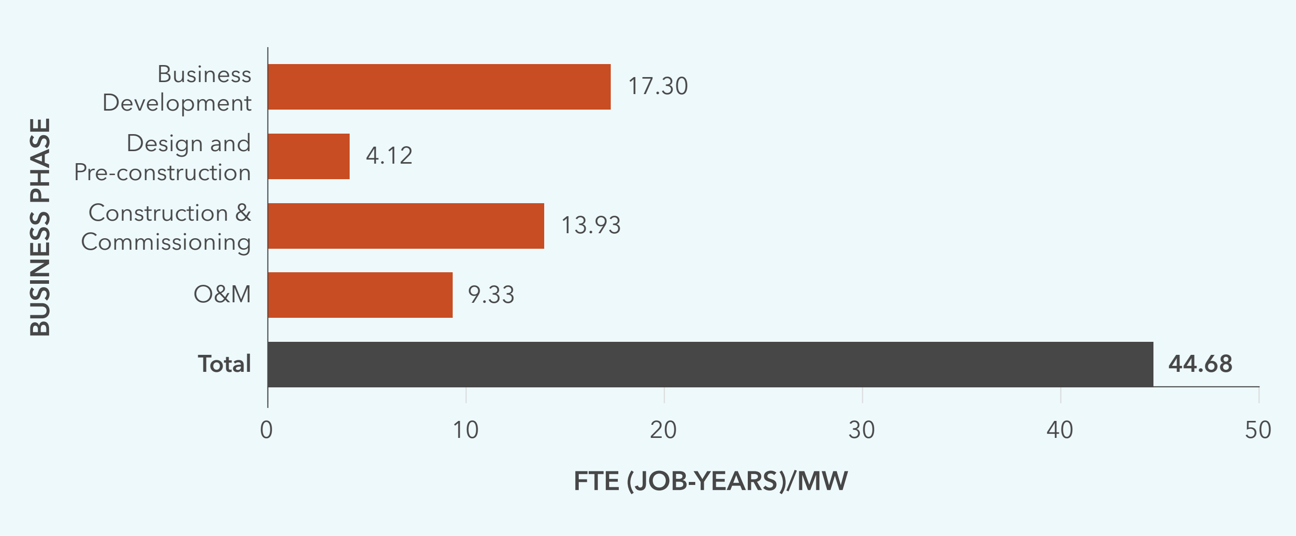
Figure 5: Phase-wise FTE Employment Coefficients for Floating Solar Sector



Source: CEEW-NRDC Analysis, 2026

xi The difference in the potential estimates in the two sources is due to a difference in methodology. MNRE and NISE study estimates solar potential only on wastelands, using Land Use Land Cover (LULC) data provided by the National Remote Sensing Centre (NRSC). In contrast, the CEEW analysis considers a broader range of land types and draws on LULC data from the Environmental Systems Research Institute (ESRI).

Figure 6: Phase-wise FTE Employment Coefficients for Rooftop Solar Sector



Source: CEEW-NRDC Analysis, 2026

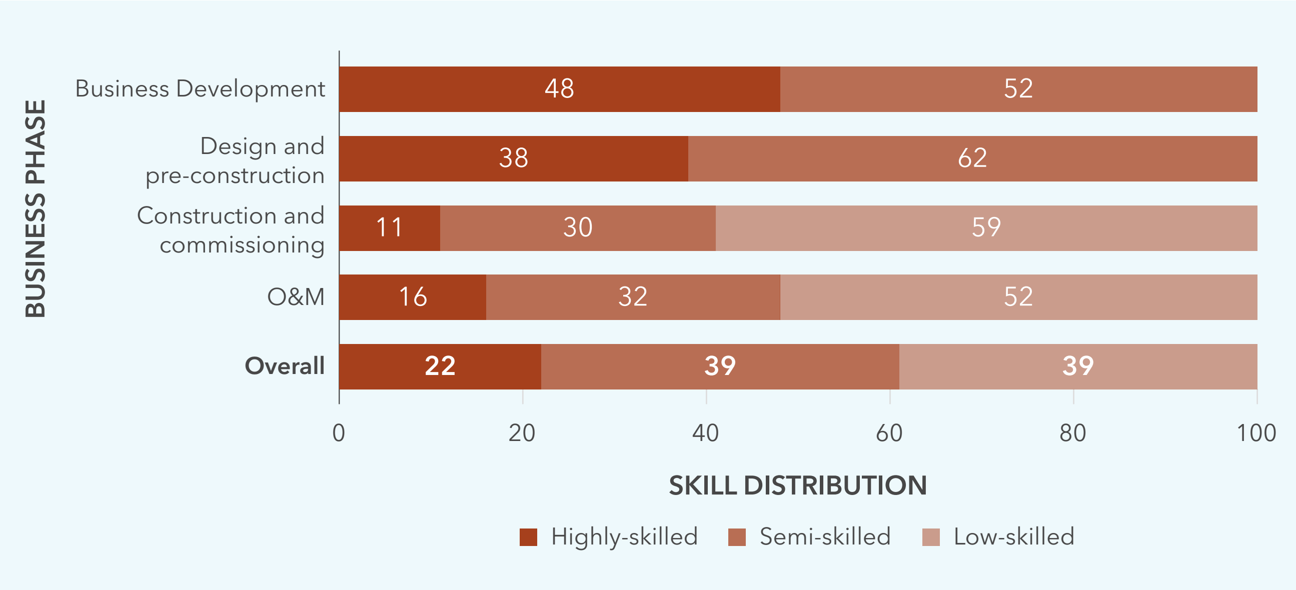
The business phase with the highest job intensity varies for each sector based on sector-specific requirements. For instance, in the case of ground-mounted solar sector, the FTE employee coefficient or job intensity is highest in the construction and commissioning phase (45 percent of the total FTE). For rooftop solar, the business development phase has the highest job intensity (38 percent of total FTE), while for floating solar, it is highest in the O&M phase (63 percent of the total FTE) (Figures 4 to 6). The construction phase is often labor-intensive due to the range of activities undertaken in the civil work. Project maintenance, on the other hand, is a recurring activity that is carried out based on the project performance and the surrounding environment.[16] For example, floating solar projects are constructed on reservoirs or lakes, which impacts the accessibility of these systems; water-based transportation is often required to reach the projects, thereby increasing the number of workers required for the maintenance phase.[17] In the case of rooftop solar, business development phase requires high customer acquisition efforts, navigating the subsidies under PM Surya Ghar Yojana and/or state subsidies, thus leading to business development having a higher employment intensity. On the other hand, the design and construction phase for the rooftop solar sector has a relatively lower job intensity as the process is more standardized (with standard calculations around solar power required as per electricity usage and roof sizes).

Skill Levels of the Workforce

Figures 7 to 9 summarize the skill sets of the workforce engaged in different project deployment phases. Overall, in the solar sector, the majority of the workers (39 percent) are semi-skilled, followed by low-skilled workers (35 percent). The deployment of ground-mounted installations is mainly driven by semi- or low-skilled workers, who represent about 78 percent of the total workforce. Meanwhile, **rooftop solar installations have the highest share of highly-skilled workforce, mainly driven by business development and design and pre-construction phases**. It must be noted that the study sample for the information on skill levels of the workforce was limited to only 23 companies for the rooftop solar sector analysis.

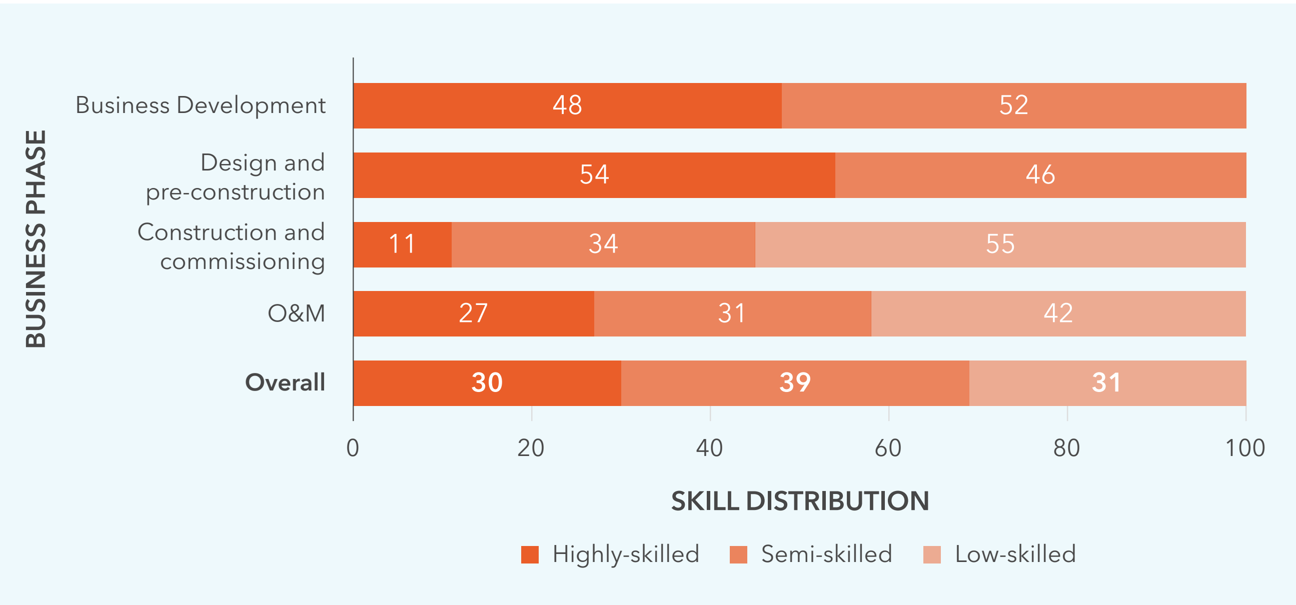
Across the three solar sub-sectors (ground-mounted, rooftop, and floating), the business development and the design and pre-construction phases **require highly- or semi-skilled workers only.** This can be attributed to the specific requirement of these roles, which involve business intelligence, networking, product knowledge, strategic thinking, financial acumen, client relationship management, land liaison, knowledge about regulations, and an understanding of market dynamics. On the other hand, the **construction and commissioning phase, across the three sub-sectors, has the highest share of low-skilled workers.**

Figure 7: Distribution of Skill Levels Across the Ground-mounted Solar Sector



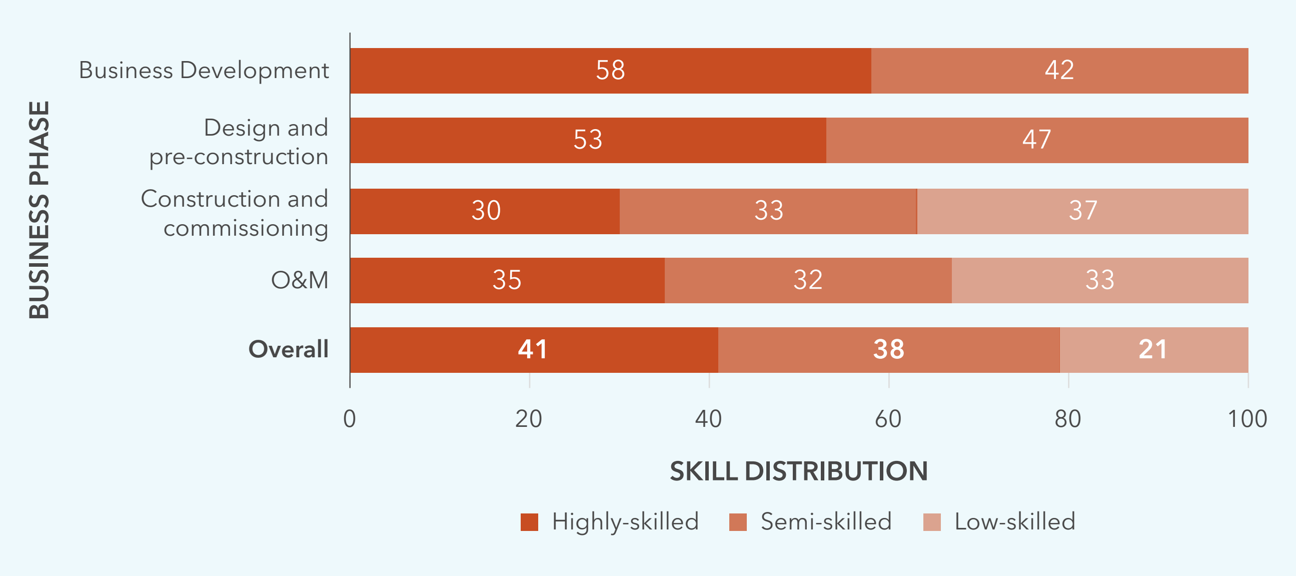
Source: CEEW-NRDC Analysis, 2026

Figure 8: Distribution of Skill Levels Across the Floating Solar Sector



Source: CEEW-NRDC Analysis, 2026

Figure 9: Distribution of Skill Levels Across the Rooftop Solar Sector



Source: CEEW-NRDC Analysis, 2026

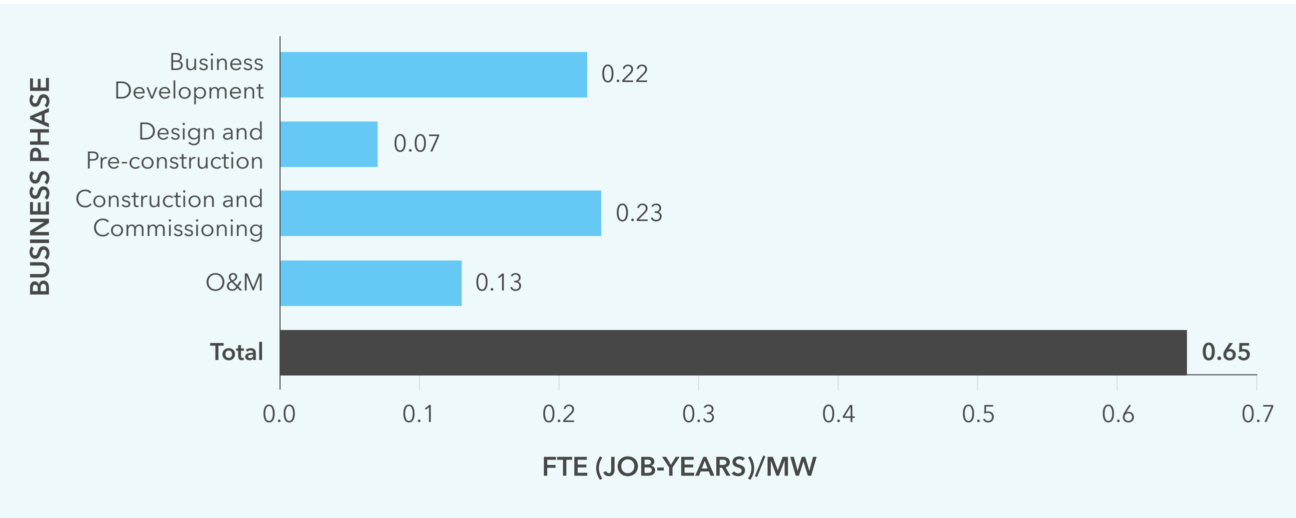
4.2 Wind

Wind is an important clean energy source for India. It can be deployed both onshore and offshore. While offshore wind installations are yet to materialize, India has a mature onshore wind generation industry. As of March 2026, the cumulative installed wind energy capacity reached 56 GW.[18]

Employment Coefficient

Based on the survey responses, the deployment of a MW capacity onshore wind project generates about 0.65 FTE (job-years)/MW (Figure 10). The maximum number of jobs per MW per year is created in the construction and commissioning phase (35 percent of total), closely followed by the business development phase (34 percent of total).

Figure 10: Phase-wise FTE Employment Coefficients for Wind Project Deployment

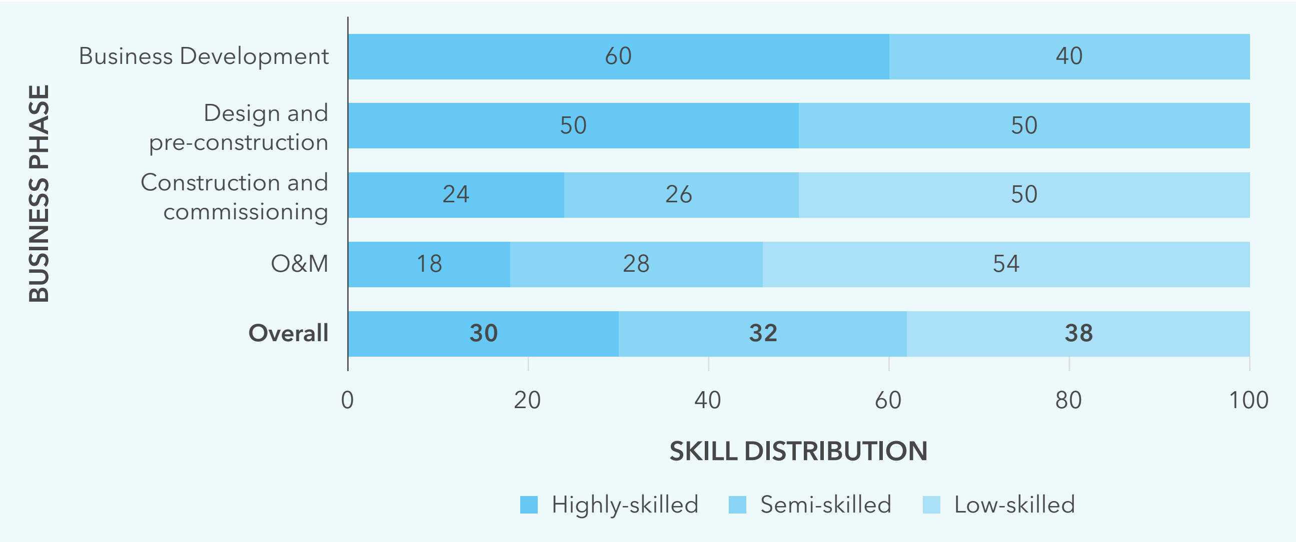


Source: CEEW-NRDC Analysis, 2026

Skill Levels of the Workforce

Approximately **62 percent of the jobs created in the wind deployment sector require highly- or semi-skilled workers** (Figure 11). While the share of highly-skilled workers is more than 50 percent in the business development and design and pre-construction phases, about 50 percent of the total workforce required in the operations and maintenance and construction and commissioning phases is low-skilled.

Figure 11: Distribution of Skill Levels Across the Wind Deployment Sector



Source: CEEW-NRDC Analysis, 2026

4.3 Bioenergy

Bioenergy is a promising clean energy source and can be obtained in various forms, such as Compressed biogas (CBG), using biomass to power, and biogas. This sector has varying business and operational models of collecting feedstock, such as having dedicated employees for collection or contracting a third party to collect and supply feedstock. This study has developed FTEs for the CBG and biomass to power sectors, along with FTEs for collection of feedstock and for pellet manufacturing. Additionally, case studies are discussed for the biogas (flexi model) and biodigester manufacturing, under sections 4.8 and 5.5 below.

4.3.1 Compressed Biogas (CBG)

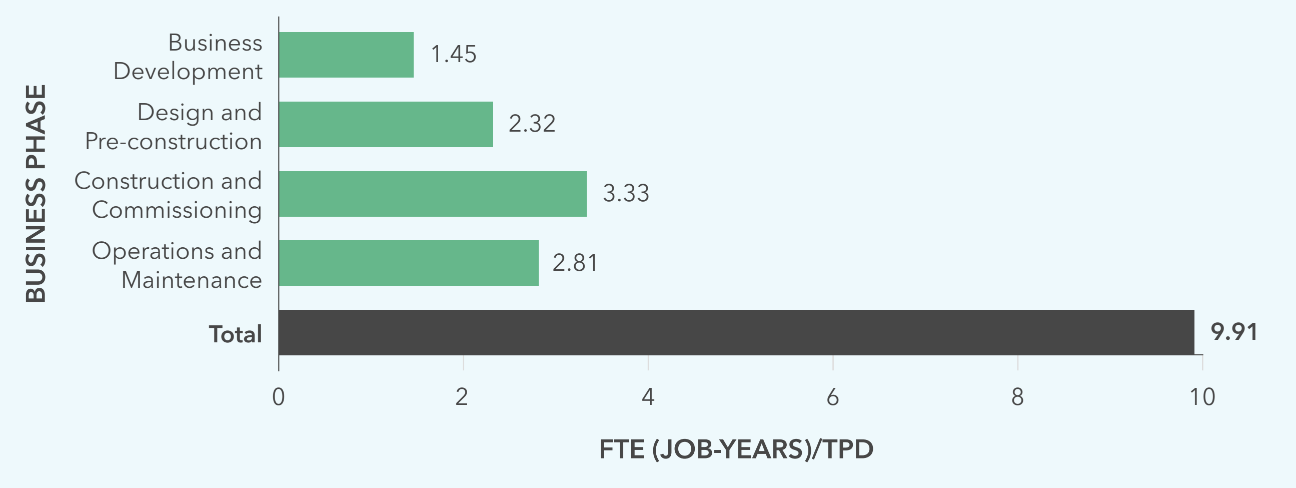
CBG is produced from biomass residue and waste through the process of anaerobic decomposition. As per the Sustainable Alternative Towards Affordable Transportation (SATAT) portal, India has 138 commissioned CBG plants and 96,513 tons of CBG sold in FY26, with capacities ranging from 2 TPD to more than 33 TPD.[19]

Employment Coefficient

Based on survey responses from nine CBG producers, a CBG project creates 9.91 FTE (job-years)/TPD for every unit of processing capacity (measured in tons per day) (Figure 12). The construction and commissioning phase create the highest number of jobs (34 percent), followed by the O&M phase, which contributes 28 percent to the total FTE.

The FTE for feedstock collection and transportation activities has been calculated using limited data (received from only five companies). The calculated FTE for this phase is 5.63 FTE (job-years)/TPD (not displayed below). The feedstock collection phase is more jobs-intensive than the construction and commissioning phase (3.33 FTE (job-years)/TPD).

Figure 12: Phase-wise FTE Employment Coefficients for CBG Sector

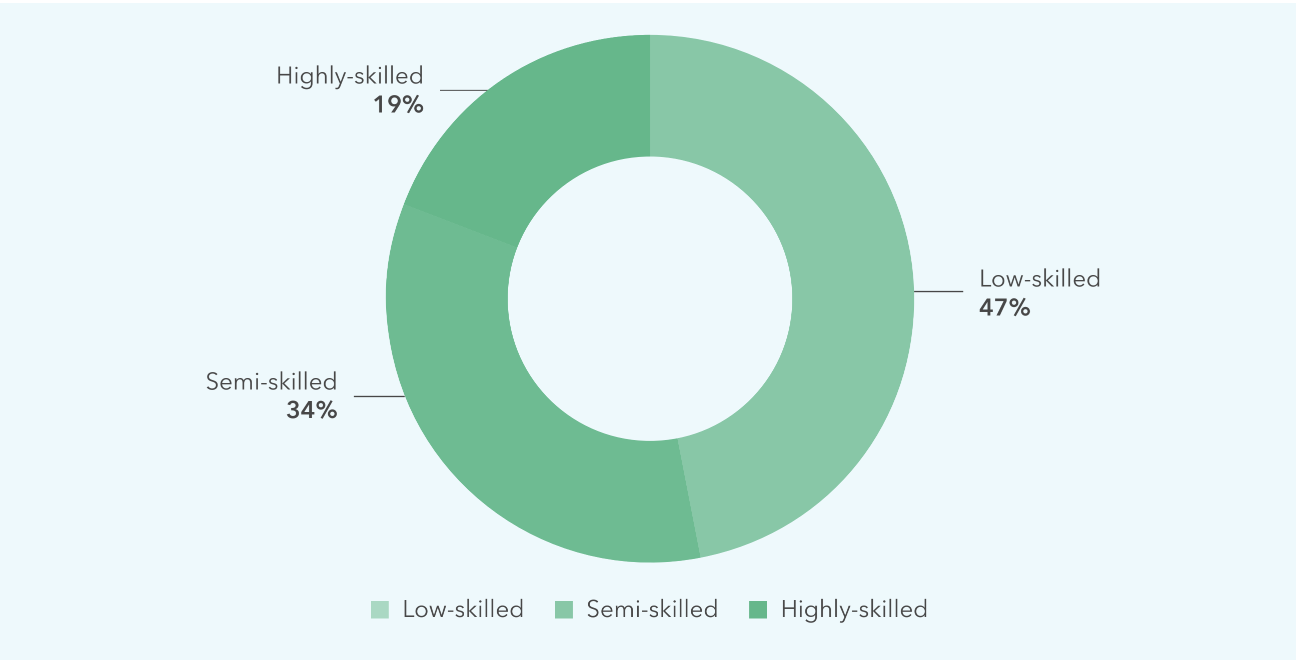


Source: CEEW-NRDC Analysis, 2026

Skill Levels of the Workforce

The CBG sector employs a significant number of low-skilled workers. Across different phases, the contribution of low-skilled workers is approximately 47 percent (Figure 13).

Figure 13: Distribution of Skill Levels Across the CBG Sector



Source: CEEW-NRDC Analysis, 2026

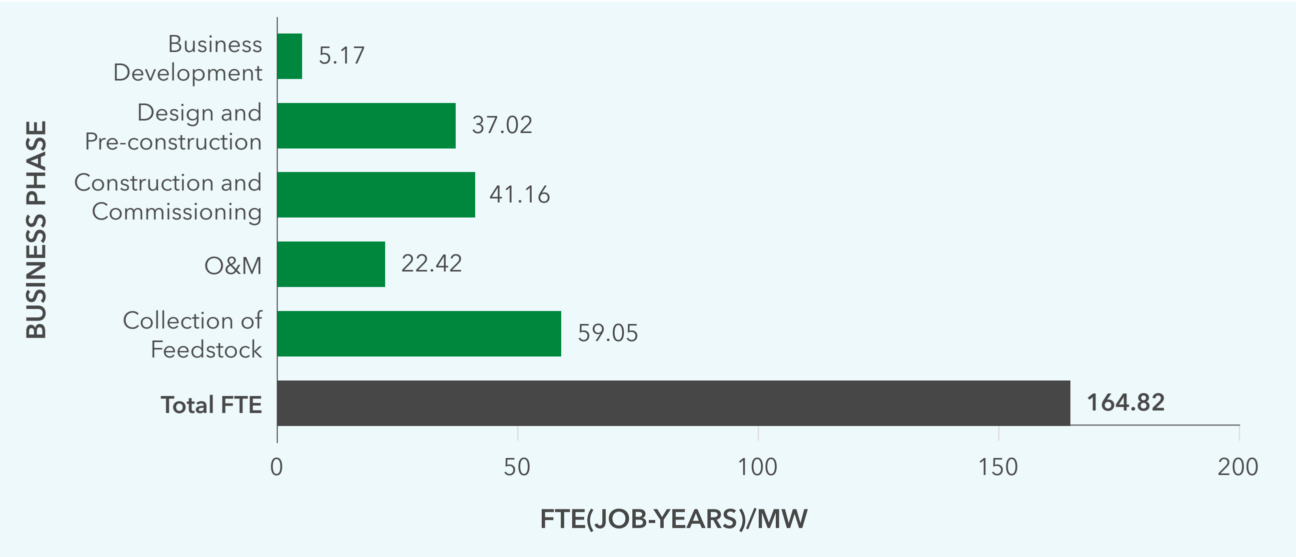
4.3.2 Biomass to Power

Biomass to power involves the use of bagasse and non-bagasse biomass for power generation activities. Non-bagasse biomass includes the use of crop residues of crops such as rice, wheat, and others. Currently, India has 9,821 MW of bagasse and 1047 MW of non-bagasse installed biomass power capacity.[20] While Maharashtra leads in bagasse-based biomass power, Punjab leads in non-bagasse-based biomass power.

Employment Coefficient

Currently, a Biomass to power project generates a total of 164.82 FTE (job-years)/MW (Figure 14). This is primarily driven by the labor-intensive process of feedstock collection (contributing over 35 percent to the FTE), followed by the construction phase (contributing to 25 percent of the FTE).

Figure 14: Phase-wise FTE Employment Coefficients for Biomass to Power Sector

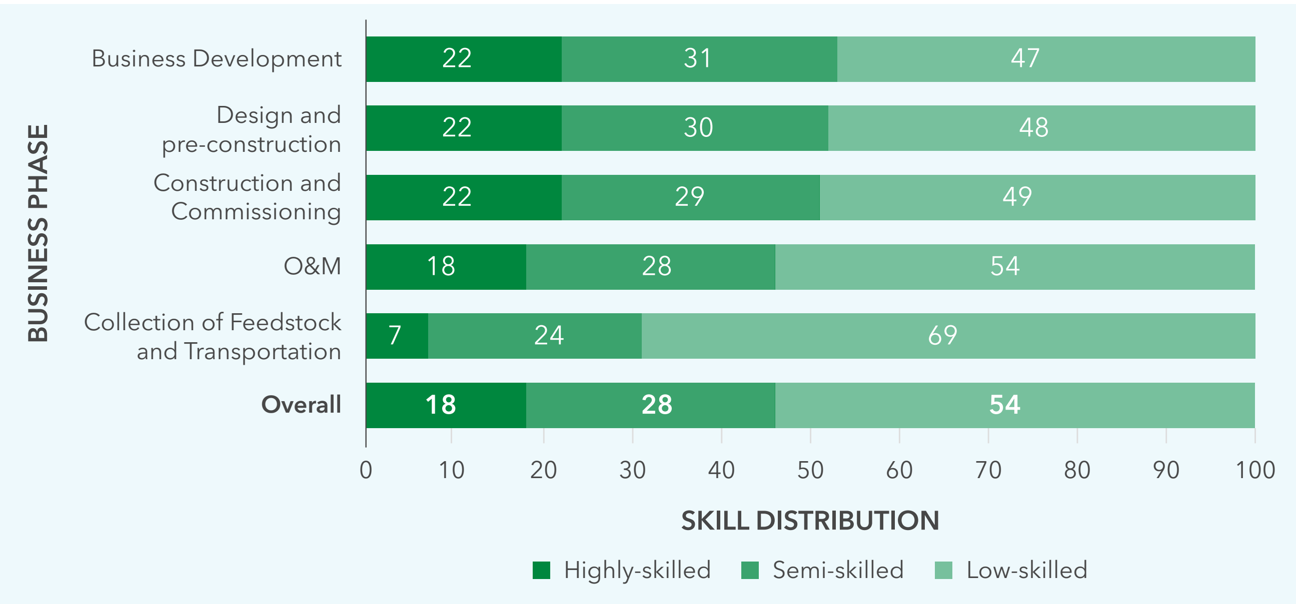


Source: CEEW-NRDC Analysis, 2026

Skill Levels of the Workforce

This sector relies predominantly on a low-skilled workforce. The collection and transportation phase has the highest number of low-skilled workforce, where almost 70 percent of the requirement is for low-skilled workers (Figure 15). The proportion of semi-skilled workforce is between 24 and 30 percent across all phases. Highly-skilled workers are least prominent in the collection of feedstock and transportation phase.

Figure 15: Distribution of Skill Levels Across the Biomass to Power Sector



Source: CEEW-NRDC Analysis, 2026

4.4 Large Hydropower

As of March 2026, India had installed 51.41 GW of large hydropower capacity in the country. The majority of the large hydropower projects are installed in Himachal Pradesh, Uttarakhand, and Karnataka.[21]

Employment Coefficient

As mentioned in Section 3, only the employment created during the O&M phase is estimated for the large hydropower sector as part of this study. This is derived from examining the current workforce engaged in 20 projects of one company. Based on these responses, the O&M phase creates about 0.72 FTE (job-years) per MW. No data was shared on the skill level requirements for any projects in this sector.

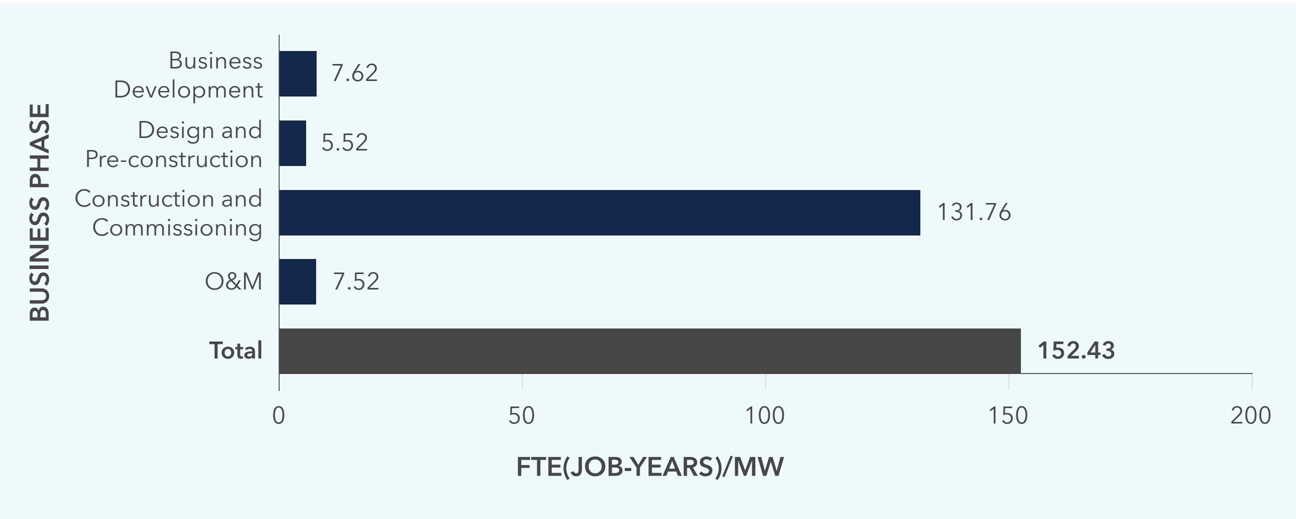
4.5 Small Hydropower

In India, a hydropower project with a capacity less than or equal to 25 MW is considered a small hydropower project.[22] As of March 2026, India had about 5 GW of installed capacity of small hydropower.[23] Small hydropower plants can remain operational for decades and thus have a longer life as compared to solar and wind plants.

Employment Coefficient

The small hydropower sector has a total FTE of 152.43 FTE (job-years)/MW. The construction and commissioning phase has the highest workforce requirement, making up 86 percent of the FTE in the small hydropower sector. The FTEs for the O&M and business development phases have similar labor intensities.

Figure 16: Phase-wise FTE Employment Coefficients for Small Hydropower Sector

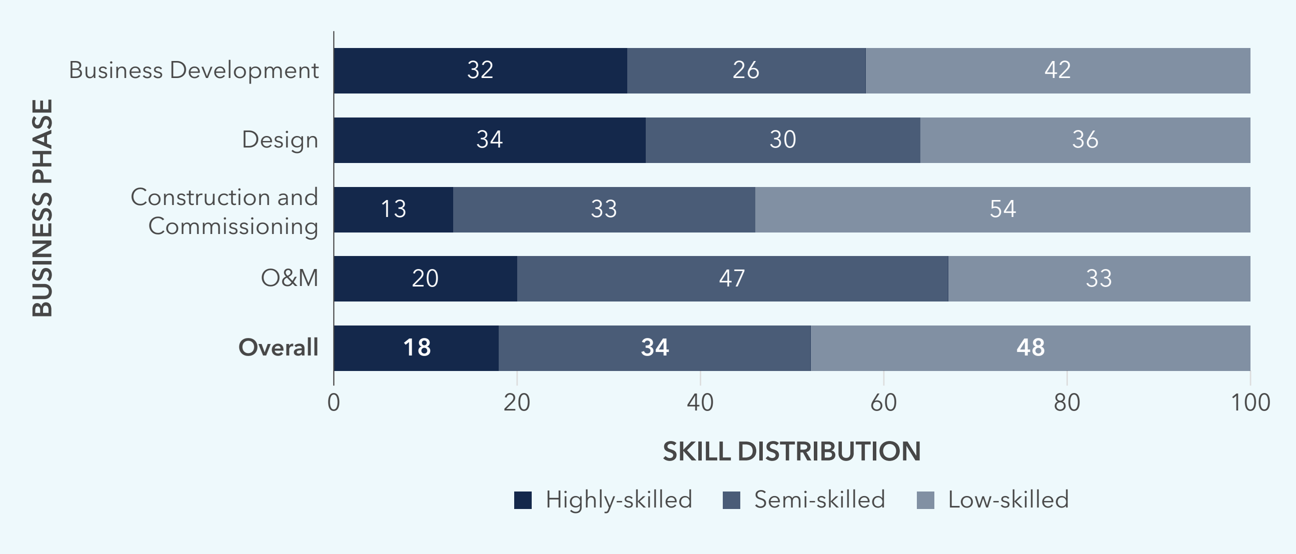


Source: CEEW-NRDC Analysis, 2026

Skill Levels of the Workforce

48 percent of the total jobs in the small hydropower sector require low-skilled workers (Figure 17). In the construction and commissioning phase, 54 percent of the total workforce is made up of low-skilled workers. While all other phases require a majority of low-skilled workers, the O&M phase is an exception where most workers belong to the semi-skilled category.

Figure 17: Distribution of Skill Levels Across the SHP Sector



Source: CEEW-NRDC Analysis, 2026

4.6 Solar Pumps Installation

Installation of groundwater water pumping systems powered by solar energy (solar pumps) across the country have been boosted by the Government of India's Pradhan Mantri Kisan Urja Suraksha Evam Utthaan Mahabhiyan (PM-KUSUM) scheme (under Component B). While the pump sizes typically vary from 2.5 HP to 10 HP, the 5 HP pumps are the most commonly installed ones in India. The solar power panel installed, as part of the solar pump installation, is standardized with the associated motor-generator set power. For example, a 5 HP motor pump set is installed with a 5 kW solar panel.

The survey questionnaire for this report's study received responses from nine companies on 11 projects. The overall installation data and the associated employees involved varied widely between projects and companies, and consensus could not be reached even through industry validation. Therefore, the FTE employment coefficient for the solar pumps installation sector was calculated by adding the FTE for motor pump sets with the FTE for a typical rooftop solar installation of 5 kW (Table 5). Installation of a typical rooftop solar is similar to that of the solar power associated with pumps, given the similar structure and electrical and solar components.

Table 5: FTE Calculation for Installation of Solar Pump

	FTE (job-years)/MW
Installation of Solar Component*	47.323
Installation of Motor Pump Set	0.586
Total FTE/MW	**47.909**

Note:
** Used the FTE for installation of a 5 kW rooftop solar system*

Source: CEEW-NRDC Analysis, 2026

4.7 Case Study: Employment Trends in Solar Mini-grids Deployment

Mini-grids are small renewable energy systems combined with a battery or generator that provides electricity.[24] As noted by a World Bank report, solar mini-grids can provide high-quality uninterrupted electricity to nearly half a billion people in unpowered or underserved communities and be a least-cost solution to reduce the energy access gap.[25] India currently lacks a dedicated national mini-grid policy. However, some states, such as Bihar and Jharkhand, have implemented solar mini-grid policies.

The survey received two responses from the mini-grid sector (Table 6). The first one was from a 0.1 MW plant that took 120 days to complete and employed about 120 people across business phases. Further, the O&M activities were conducted for approximately 300 days per year. The second response was from a 1 MW plant that took approximately 80 days from business development to commissioning, and required an additional 32 days per year for O&M.

Table 6: Workers Needed to Deploy Two Mini-grid Projects of Varying Capacities

	0.1 MW Plant			1 MW Plant		
	Number of Workers	Duration of the Phase (days)	Time Spent by Workers on this Project	Number of Workers	Duration of the Phase (days)	Time Spent by Workers on this Project
Business Development	2	40	100%	4	30	50%
Design	2	40	100%	10	30	50%
Construction and Commissioning	11	40	100%	10	21	50%
Operations and Maintenance	1	296	100 %	9	32	50%
Total	**16**	**416**		**33**	**113**	

Source: CEEW-NRDC Analysis, 2026

Based on Table 6, while the construction and commissioning phase generated higher person-day[xii] requirements for the smaller plant, the design phase generated higher person-days for the larger plant. This may be due to the larger area covered by bigger systems, and the resulting need for extensive planning prior to construction.

By providing an efficient source of electricity supply and cutting down transmission losses, mini-grids offer reliability in more remote, inaccessible areas where power grid reliability is often low. Simultaneously, mini-grids offer job opportunities to locals especially in long-term O&M activities and can drive economic growth in rural communities.[26]

The survey results also revealed that mini-grid deployment requires a combination of technical skills in electrical engineering and solar system design, operational capabilities in troubleshooting and maintenance, and soft skills including problem-solving, adaptability, training, handover, and collaboration skills.

xii Person-days is calculated by multiplying the number of people involved by the number of days they worked

4.8 Case Study: Employment Trends in Biogas Deployment

The MNRE's National Bioenergy Programme (NBP), with a provision of Central Financial Assistance, aims to support biogas plants that provide clean cooking fuel and electricity while reducing greenhouse gas emissions and improving sanitation. As of March 2025, 51 lakh (5.1 million) biogas plants have been set up in India. Maharashtra, Karnataka, and Uttar Pradesh are the leading states in biogas plant installations.[27]

The survey for this study received responses from two companies—one for a 2 cubic meter plant and the other for two 40 cubic meter plants (Table 7). Both companies employed a similar number of workers for a comparable number of days, but deployed projects of varying capacities.

Table 7: Comparison of Workers Needed to Deploy Biogas Plants of Different Sizes

Business Phase	2 cubic meter plant			40 cubic meter plant X 2 Nos.		
	Number of Workers	Number of Women	Duration (days)	Number of workers	Number of Women	Duration (days)
Business Development	4	1	15	3	1	75
Installation	8	1	20	12	4	5
Operations	3	1	365	2	0	365
Maintenance	3	1	1	2	0	7
Total	**16**	**4**	**401**	**19**	**5**	**452**

Source: CEEW-NRDC Analysis, 2026

Based on Table 7, the operations phase of a biogas plant has the highest requirement of person-days in the case of both plants. While maintenance activities are typically scheduled annually, they may occur more frequently as needed.

Both the companies in the sample have women employees, however, there is an opportunity for greater participation of women in the workforce. Given that rural areas have a high potential for biogas deployment, increasing awareness, participation, and training of rural women can help this clean fuel technology become more widely accepted among the rural communities, along with enabling higher participation of women in the deployment of biogas energy.

4.9 Case Study: Employment Trends in Solar Street Light Deployment

India's solar street lighting sector is experiencing rapid growth, fuelled by a growing demand for sustainable, energy-efficient infrastructure across both rural and urban landscapes. Government initiatives like Atal Jyoti Yojana and Smart Cities Mission are key drivers, contributing to a market valued at USD 1.07 billion in 2024, with an expected Compound Annual Growth Rate of 14.21 percent (over the period from 2025 to 2033).[28] Solar street lighting systems are typically composed of photovoltaic panels, LED luminaires, batteries, charge controllers, and mounting poles.[29] Most of these parts—like the pole, panel, and charge controller—are made in India. However, some important components like batteries and LED chips still need to be imported. The inherent modularity of solar street lighting systems allows them to be assembled with minimal technical training and thus makes them ideal for decentralized deployment by self-help groups, local entrepreneurs, women, and rural youth.

In many states, local governments and panchayats (local village councils) manage the procurement and installation of solar streetlights through urban and rural development programs and state subsidies support. Such a decentralized system, however, makes it difficult to get the specific deployment, installation, and employment data.

The survey received a detailed response on the employment opportunities created by the deployment of solar streetlights from one company, offering valuable insights.

We received data on solar streetlight manufacturing from one company that produces and installs 50,000 streetlights a year. Table 8 lists the number of workers needed by the company across the phases of deploying and manufacturing solar streetlights. As the company also has various other work verticals, the proportion of time spent by the company on producing and installing solar streetlights has also been mentioned in Table 8.

Table 8: Workers Needed to Deploy and Manufacture Solar Street Lights

Business Phase	Number of Workers	Time Spent by Company on Solar Streetlights
Material Procurement	2	15%
Technical Support	4	15%
Production	25	30%
Business Development	4	15%
Corporate	2	100%
Systems Installation	35	30%
O&M	15	20%

Source: CEEW-NRDC Analysis, 2026

The data from Table 8 highlights that the systems installation and production phases have the highest workforce requirements, as both the processes of system installation in the field and the manufacturing and assembling of components are labor-intensive roles. A smaller but steady workforce is required for operation and maintenance activities, while there are relatively fewer workforce requirements in the corporate, business development, technical support, and material procurement phases, which are more specialized.

Participation of women in the workforce is most visible (25 to 30 percent) in the material procurement phase, with lower representation in technical and installation roles. Encouragingly, the company has initiated training programs to upskill women for roles in the production and manufacturing phases.

Despite promising data, these findings are not representative of the broader industry, underscoring the need for wider engagement. For example, training self-help groups in rural areas can lead to greater support for women-led operations and maintenance, however, the informal nature of their operations makes their impact hard to trace and quantify. Addressing these gaps is vital for scaling and sustaining clean energy initiatives and efforts.

Box 1: Insights on Skill Requirements in the Deployment Sectors

The survey questionnaires were designed not only to identify the skill levels across the job profiles in different phases of the projects, but also to generate insights into the specific skillsets needed at each stage. This dual lensed analysis of the data provides a deeper understanding of workforce requirements in the clean energy sector. The phase-wise organized findings are summarized in Table 9 below.

Table 9: Summary of Skills Required Across Different Phases of Deployment

S. No.	Phase	Key Skills Required
1	**General/Cross-cutting Skills**	Business Communication; Technical Proficiency; Regulatory Knowledge; Quality Assurance; Civil, Mechanical, & Electrical Engineering; Remote Monitoring & Preventive Maintenance; Prior RE Sector Knowledge/Experience
2	**Business Development**	Business Intelligence; Knowledge of Ecosystem Partners; Product Knowledge; Project Management & Strategic Thinking; Financial acumen; Regulatory Knowledge; Client Relationship Management; Sales; Land Liaison; Market Dynamics Understanding
3	**Design & Pre-Construction**	Project Management; Troubleshooting; Electrical Engineering; AutoCAD & Technical Software Proficiency; Quality Assurance; Construction Knowledge; Environmental Impact Analysis (esp. for hydropower sector); Site Assessment & Surveying; Civil & Mechanical Engineering; Sustainability Planning; DPR Preparation; Structural & Hydraulic Design Optimization; Risk Assessment & Mitigation in Design
4	**Construction & Commissioning**	Civil, Mechanical & electrical Engineering; Communication, Coordination & Negotiation; Teamwork & Leadership; Decision-making; Construction Knowledge; Commissioning Management Systems; Hydraulic & Hydro-mechanical Engineering; Grid Integration; Land Procurement/Right-of-way Experience
5	**O&M**	Remote Monitoring; Preventive Maintenance; Safety; SCADA & Automation System Management; Environmental Monitoring & compliance; Electrical Maintenance & Troubleshooting; Mechanical Equipment Maintenance & Management; Advanced Software & Data Analysis; Forecasting

Source: CEEW-NRDC Analysis, 2026

In the case of business development-oriented work, these are some of the key skills that are found to be currently lacking in the workforce—limited expertise in project proposal and grant writing, knowledge of incentives and subsidies available for the renewable energy sector, and insufficient exposure to international market expansion. Further, the lack of expertise in skills such as digital marketing, contract negotiation, and bidding may affect the tender bidding process and effective scale-up or expansion in diverse domestic and potentially international markets.

5. EMPLOYMENT TRENDS IN THE CLEAN ENERGY MANUFACTURING SECTORS

The study has examined the manufacturing of crystalline silicon-based solar modules, wind turbines, and solar pumps in the clean energy manufacturing sectors. This section discusses the employment opportunities and skills required for these three sectors.

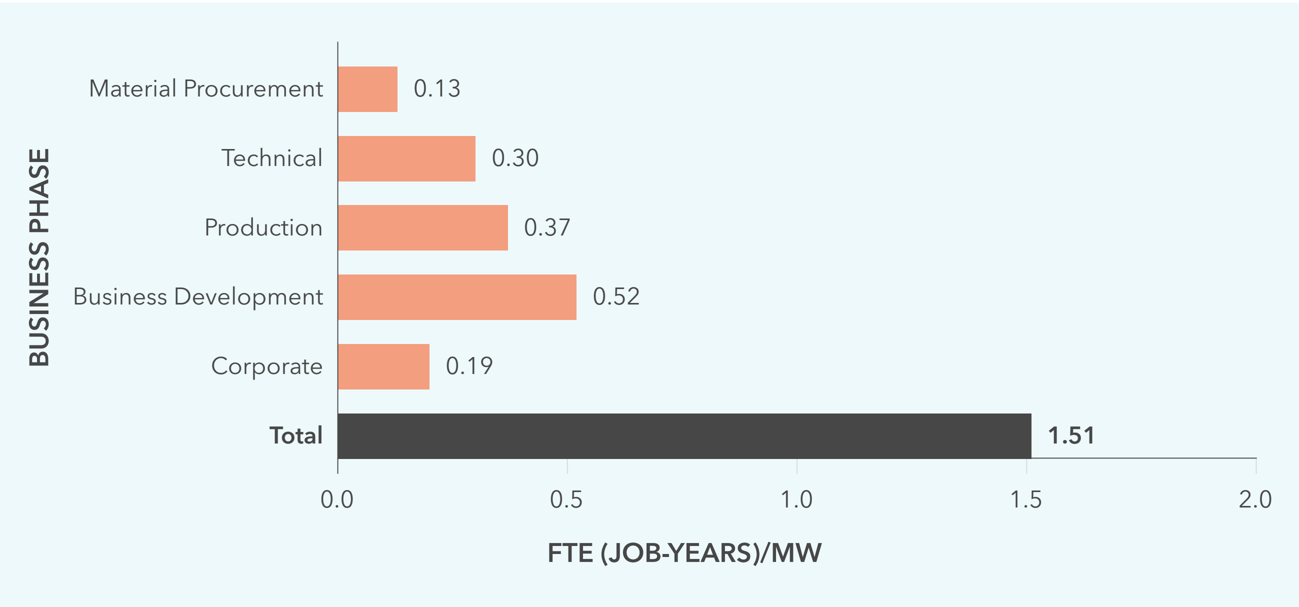
5.1 Solar Module Manufacturing

India's solar module manufacturing has grown over the last couple of years and stands at about 90 GW of nameplate capacity (i.e., maximum theoretical power output in ideal conditions) as of June 2025.[30] Although the domestic industry is expanding, India remains a net importer of solar modules.[31] Currently, China dominates about 77 percent of the global supply chain for solar modules, including the machinery for solar module manufacturing.[27] Solar module manufacturing units employ continuous assembly lines that are largely automated. Hence, the process is standardized across companies, and human intervention in production processes is limited. The focus of this report is limited to module assembly. The FTE employment coefficient excludes cell and wafer manufacturing.

Employment Coefficient

According to the survey and data analysis, solar module manufacturing has a labor intensity of 1.51 FTE (job-years)/MW. This is primarily driven by the business development phase, followed by the production phase.

Figure 18: Phase-wise FTE Employment Coefficients for Solar Module Manufacturing Sector

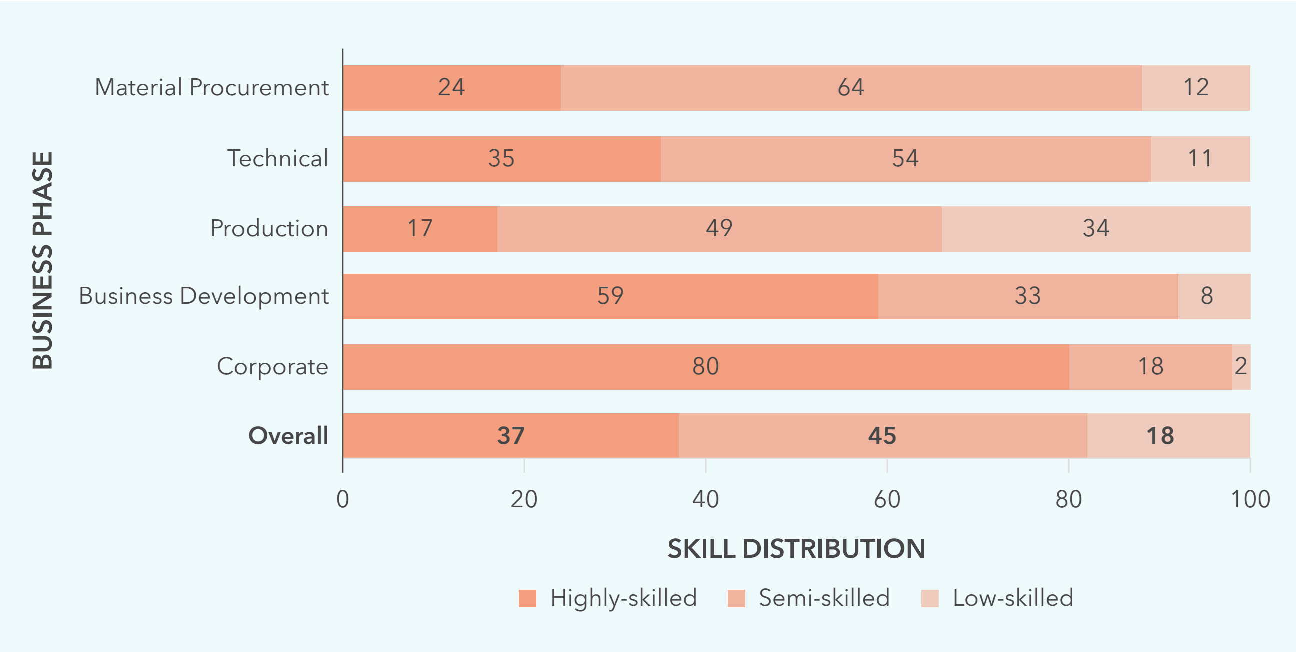


Source: CEEW-NRDC Analysis, 2026

Skill Levels of the Workforce

The solar module manufacturing sector primarily requires highly- and semi-skilled workers (Figure 19). While the business development and corporate phases require a higher number of highly-skilled workers, the procurement, technical (including design), and production phases require more semi-skilled workers.

Figure 19: Distribution of Skill Levels Across the Solar Module Manufacturing Sector



Source: CEEW-NRDC Analysis, 2026

5.2 Wind Manufacturing

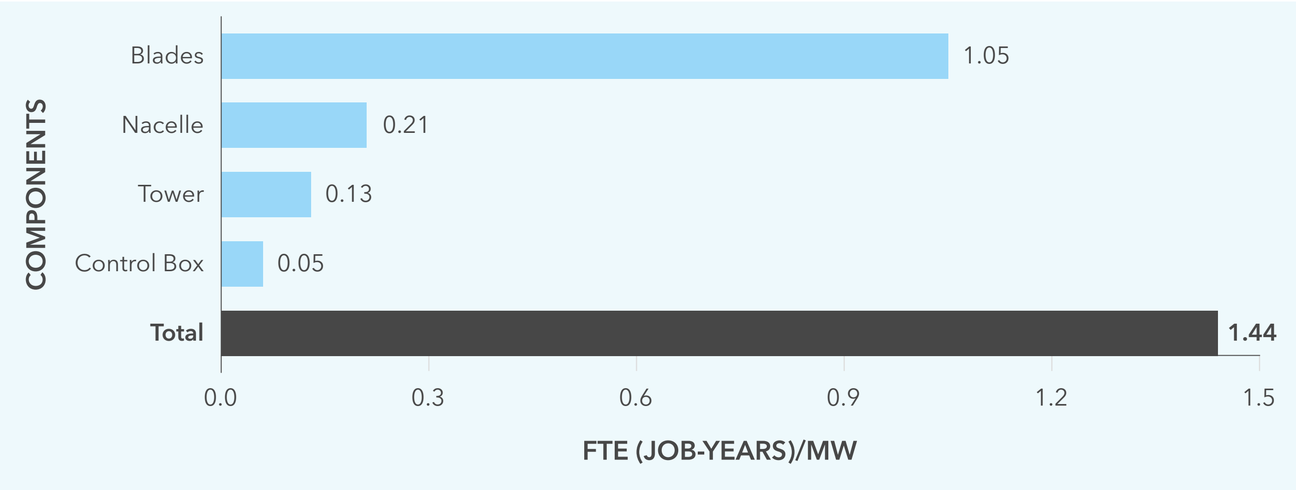
Wind manufacturing is an established renewable energy sector in India, with the current annual production capacity of 18 GW.[32] A wind turbine consists of different components, such as blades, nacelle, tower, and control box. Some companies manufacture all components, while others focus on manufacturing only some of the components. As per MNRE, India has achieved around 70 to 80 percent indigenization in wind manufacturing.[33]

It must be noted that there was a lack of response from companies in the sector to participate in the survey for this report, with only one company submitting a fully completed response. However, the respondent holds approximately 28 percent of the market share among Indian wind turbine manufacturers. The respondent also manufactures all the wind turbine components, thereby allowing an insight into the labor intensity for a vertically integrated wind turbine manufacturing company. Figure 20 shows the labor intensity for each of the different components of the wind turbine manufacturing sector.

Employment Coefficient

Among the different components of wind turbine manufacturing, blade manufacturing has the highest employment coefficient (1.05 FTE (job-years)/MW), followed by nacelle (0.206 FTE (job-years)/MW), tower (0.13 FTE (job-years)/MW), and control box (0.057 FTE (job-years)/MW). Upon adding these individual FTEs, the cumulative employment coefficient for wind turbines is calculated to be 1.44 jobs FTE (job-years)/MW.

Figure 20: Component-wise FTE Employment Coefficients for a Vertically Integrated Wind Turbine Manufacturing Facility



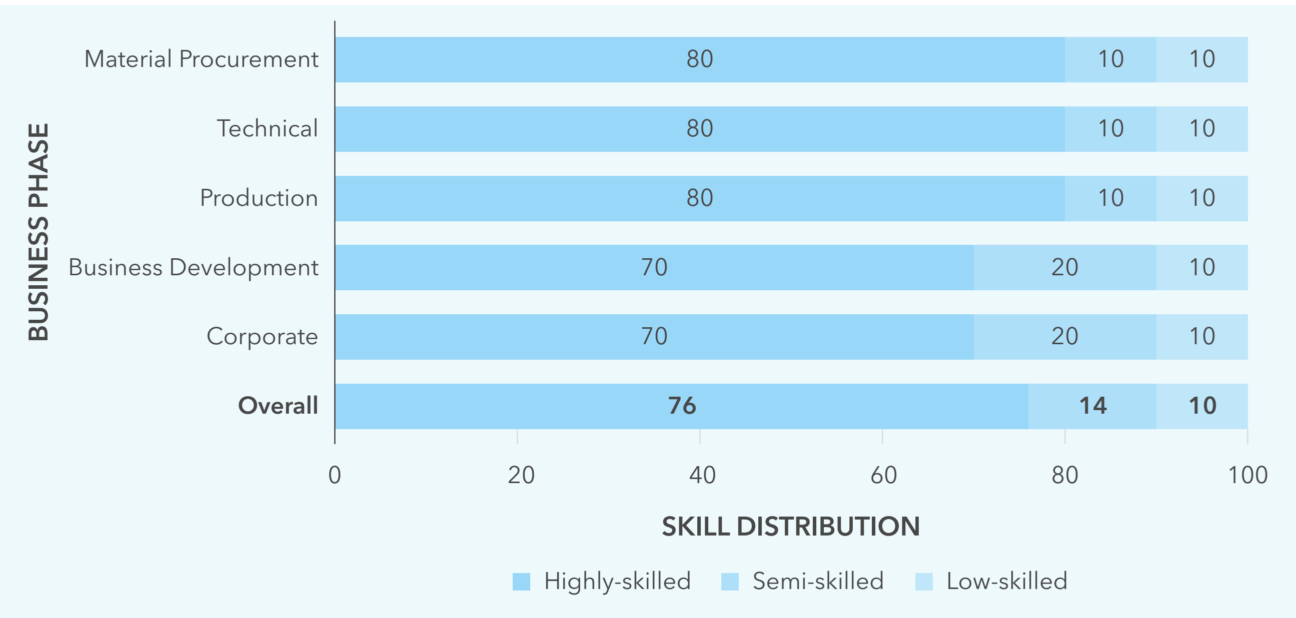
Note: Numbers rounded off to second decimal point

Source: CEEW-NRDC Analysis, 2026

Skill Levels of the Workforce

All the phases of the wind manufacturing sector primarily require a highly skilled workforce, making up 70 to 80 percent of the jobs. The proportion of semi-skilled and low-skilled workforce is similar for the procurement, technical, and production phases. Semi-skilled and low-skilled workers together make up 30 percent of the workforce in the business development and the corporate phases.

Figure 21: Distribution of Skill Levels Across the Wind Manufacturing Sector



Source: CEEW-NRDC Analysis, 2026

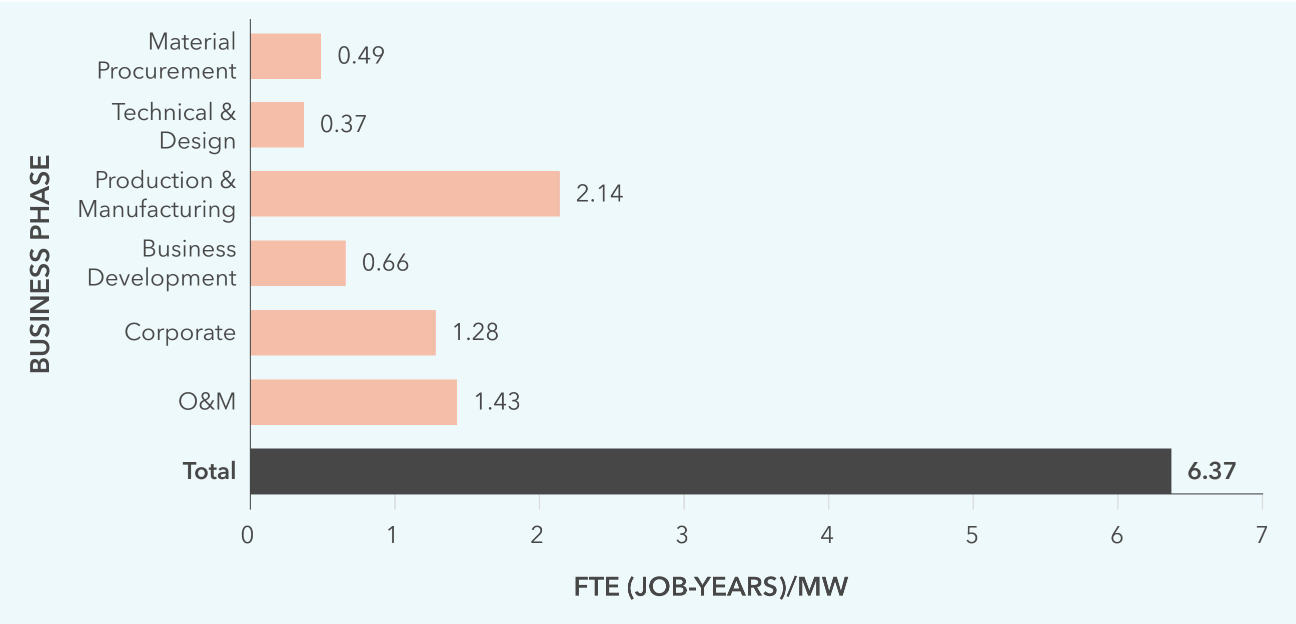
5.3 Solar Pumps

Solar pump manufacturing is one of the key segments of the decentralized solar energy sector. As per MNRE, about 7,70,777 standalone solar pumps, of up to 7.5 HP capacity, have been installed in India, as of March 2025, under various components of the PM-KUSUM Scheme.[34]

Employment Coefficient

Based on the responses received in the survey for this report, the solar pump manufacturing industry generates 6.37 FTE (job-years) per MW (Figure 22). The production phase is the most labor-intensive, accounting for more than 32 percent of the overall FTE.

Figure 22: Phase-wise FTE Employment Coefficients for Solar Pump Manufacturing Sector

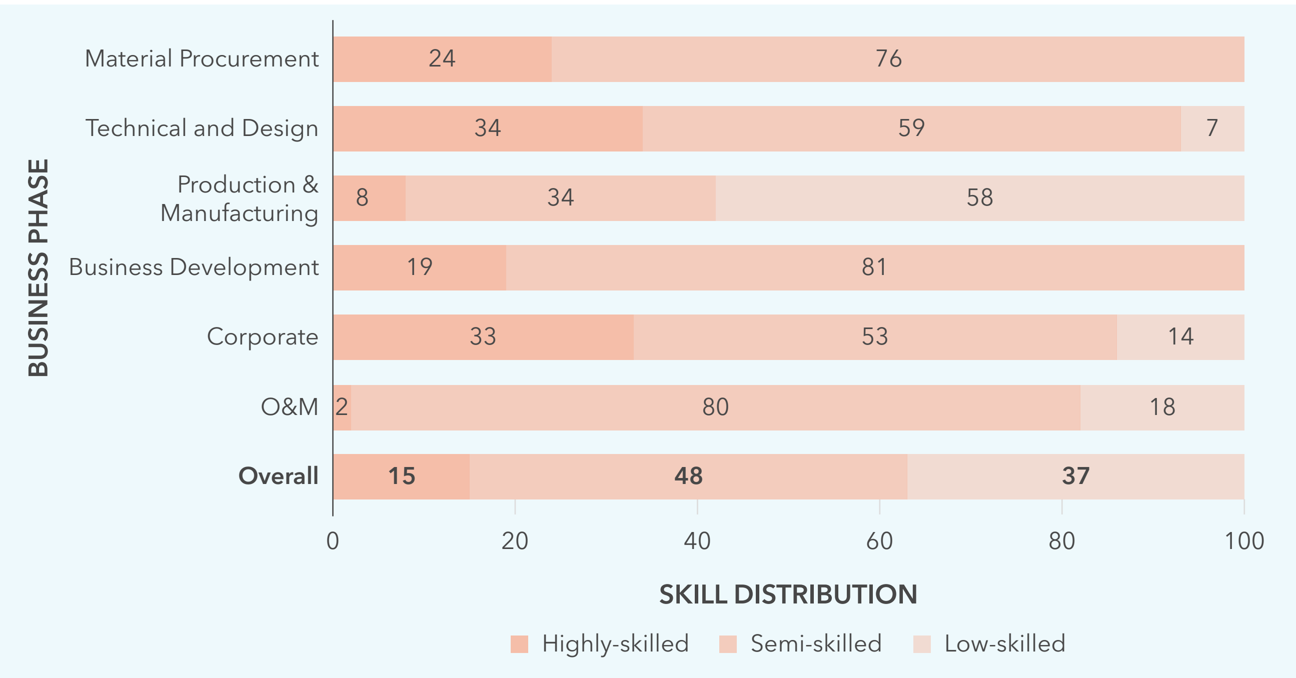


Source: CEEW-NRDC Analysis, 2026

Skill Levels of the Workforce

Figure 23 shows the distribution of skills across the various business phases of the solar pumps manufacturing sector. According to the survey, the sector comprises primarily of semi-skilled workers, representing 48 percent of the overall workforce, followed by low-skilled workers, which account for 37 percent of the workforce.

Figure 23: Distribution of Skill Levels Across the Solar Pump Manufacturing Sector



Source: CEEW-NRDC Analysis, 2026

5.4 Biomass Pellet Manufacturing

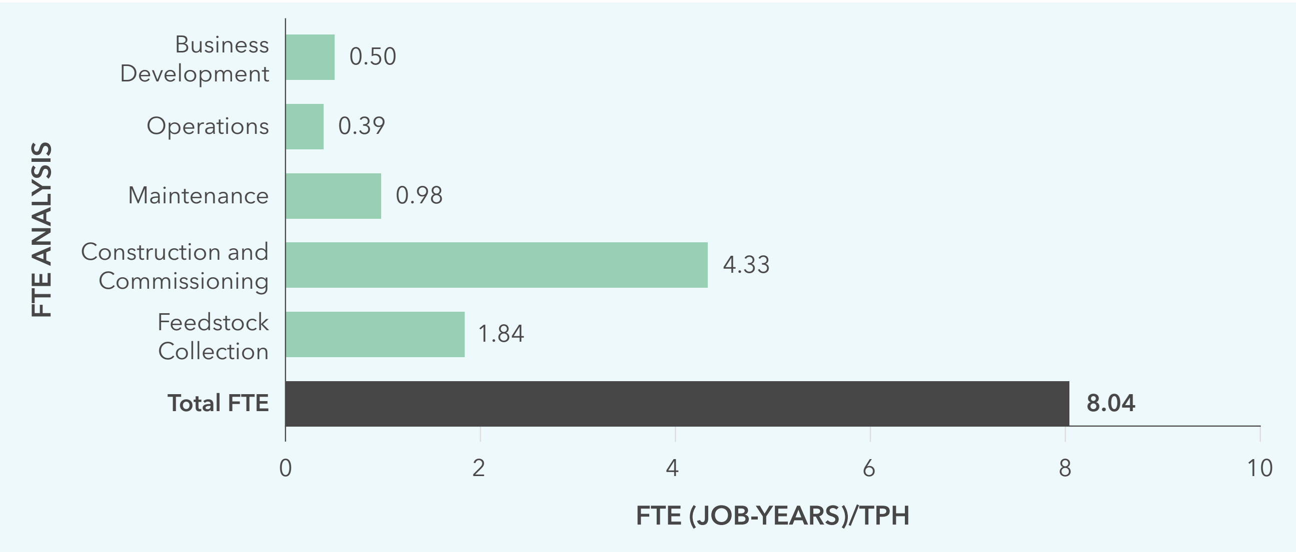
The biomass pellet and briquette manufacturing industry in India comprises more than 5,500 operational facilities, typically producing between 1,300 kg/hr and 1,700 kg/hr (data based on stakeholder consultations) of energy. Under the Biomass Program of the MNRE, central financial assistance is provided to help set up biomass pellet and briquette manufacturing plants.

Employment Coefficient

Following the data validation process, the study used data from 6 out of the 15 companies that had responded to the survey. The companies in the final sample have manufacturing plants with an energy output of 2.5 to 7 tons per hour (TPH). Based on the analysis, the biomass pellet manufacturing sector generates 8.04 FTE (job-years)/TPH. As Figure 24 suggests, the construction of the plant phase has the highest labor-intensity, followed by the feedstock collection phase.[xiii]

In terms of the skill levels of the workforce, the study shows that 62 percent of the workforce is made up of low-skilled workers, 25 percent are semi-skilled and 13 percent are highly-skilled.

Figure 24: Phase-wise FTE Employment Coefficients for Biomass Pellet and Briquette Manufacturing Sector



Source: CEEW-NRDC Analysis, 2026

With impetus from the Biomass Programme under MNRE, this sector holds significant promise for entrepreneurial development and rural economic advancement, including skill building opportunities for rural areas.

5.5 Case Study: Employment Trends in Small Bio-digester Manufacturing

Biodigesters facilitate microbes to break down organic matter in the absence of oxygen, or anaerobic reaction, to produce biogas. The by-product of this treatment, called slurry, is used as high-quality fertilizer. Biodigesters are relatively simpler forms of biogas plants, typically used at domestic levels to treat sewage, farm waste, and organic waste. Over the past decade, there has been an increase in use of small

xiii Feedstock collection is seasonal, and the FTE only represents employees working on the procurement, collection, and transportation phases. Other on-ground employment generated in storage, aggregation, and other ecosystem players (such as farmer producer companies, local agents, individual farmers, and direct suppliers) are not captured in this study.

biodigesters, with various forms installed in railways facilities, farms, and remote military facilities.[35] With approximately 17 percent of India's Gross Domestic Product coming from the agricultural sector, and a livestock population of 535.78 million, the central government considers the biogas and biodigester sector to be important sources of clean energy. The MNRE, through the National Bioenergy Programme, provides central financial assistance to small biogas plants of production capacities ranging from 1 cubic metre to 25 cubic metre per day.[36]

Due to incomplete responses from other respondents, this study presents data from only two companies that manufacture small biodigester units of 2 cubic metres, with an annual capacity of 3,000 units and 12,160 units respectively (Table 10).

Table 10: Distribution of Workforce Across Phases for Two Biodigester Manufacturers

Business Phase	Manufacturer 1 with Annual Capacity of 3,000 units	Manufacturer 2 with Annual Capacity of 12,160 units
	No. of Workers	No. of Workers
Procurement	1	5
Production	2	27
Business Development	2	5
Corporate	1	5
Maintenance	2	5
Total	**8**	**47**

Source: CEEW-NRDC Analysis, 2026

Workforce requirement is equally distributed across the different phases in the case of the company with the lower manufacturing capacity. Meanwhile, in the larger company, workforce requirement is concentrated in the production phase, as it requires technical knowledge of chamber sizing, production material, and heavy manufacturing machinery. The smaller company manufactures approximately 375 units per person, compared to 250 units for the larger company.

With a relatively smaller size and simple design, biodigesters are commonly installed at the local level in rural areas, making it difficult to obtain extensive data on deployment information and system feedback.

Box 2: Insights on Skill Requirements in the Manufacturing Sectors

In both the wind turbine and solar module manufacturing sectors, survey respondents emphasized the need for technical qualifications such as mechanical, electrical, and civil engineering; with respondents from the solar module manufacturing sector mentioning the additional requirement of technical professionals with ITI certification, diplomas, and MBAs. Equipment maintenance, finance, marketing, teamwork, and innovation were also emphasized as critical workforce competencies by respondents from the solar module manufacturing sector. Meanwhile, in the wind turbine manufacturing sector, the most highly desired skills included planning, expertise in turbine technology and instrumentation, land and liaison, automation, and analytics.

A few sector-specific technical skills were highlighted by the respondents from the solar water pumps sector. Such as some of the hydrology-specific engineering competencies (needed for solar water pumps manufacturing) include fluid dynamics integration, flow optimization, pump diagnostics and system design, along with battery-pump compatibility for energy storage. Technology integration expertise spans solar-electrical systems combined with mechanical pumping, smart controllers, remote monitoring, and predictive maintenance capabilities. The installation phase in the solar water pumps sector requires proficiency in techniques that integrate electrical, plumbing, and solar components, along with water system troubleshooting abilities. Knowledge of CSR opportunities and government policy represents another essential workforce requirement.

Civil and mechanical engineering expertise emerged as a universal requirement across all the manufacturing sectors.

Image source: iStock

6. EMPLOYMENT, SKILL, AND AUTOMATION TRENDS ACROSS SECTORS

Based on the analysis of employment and skill data discussed in the previous sections, these are some of the trends identified across sectors:

Trend 1: Deployment of distributed systems is more labor intensive than utility-scale systems

As seen in Section 4 (Table 4), household-level and/or distributed clean energy sources like biomass to power, small hydropower, and rooftop solar have the highest FTE employment coefficient per installed capacity. This is due to the small size of projects (for instance, a few kW for rooftop solar systems) in these sectors, which would require a higher number of projects to reach a specific MW capacity. In order to carry out distributed installations across multiple locations, more workforce is required in the design, construction, and O&M phases. On the other hand, sectors with larger project sizes, such as ground-mounted solar, floating solar, and wind, require lesser workforce per installed capacity as a small team works at a single location over a longer duration. Additionally, in the ground-mounted solar and wind sectors, industry players leverage their capital resources to optimize deployment, resulting in higher efficiency levels and lower FTE per MW.

Trend 2: Business development phase contributes significantly to the total job opportunities across sectors

Despite overall efficiency gains, the number of workers required for business development activities is higher than other phases in sectors such as rooftop solar (38 percent of total FTE) and solar module manufacturing (32 percent of FTE). The need for more workforce in the business development phase is driven by the rapidly evolving regulatory and policy landscape, changing tender design, and challenges in land procurement. Companies now require dedicated individuals to actively track these changes and inform the company processes. Additionally, for sectors such as rooftop solar, sales processes have become more time-intensive, with longer conversion cycles from potential customers to actual users, necessitating larger sales teams.

Trend 3: About 60 percent of the jobs in the solar and wind project deployment sectors require highly- or semi-skilled workforce

The skill level trends across the solar and wind deployment sectors indicate a greater requirement for highly- or semi-skilled workforce (about 60 percent of the total jobs) as compared to low-skilled workforce (which now accounts for less than 40 percent of the jobs). The requirement for highly- and semi-skilled workers is particularly high in the business development and design and pre-construction phases. The construction and commissioning and O&M phases are the only ones with a considerable share of jobs that require low-skilled workers. An interesting trend reveals that companies are increasingly seeking to employ individuals with sector-specific (technical, financial, and analytical) skills and prior work experience in the sector. As a result, the required skill levels have gone up.

Trend 4: The skill level of the workforce in solar and wind manufacturing sectors is greater than the deployment sectors, with about 80 to 90 percent of the workforce engaged in highly- or semi-skilled jobs

The share of the low-skilled workforce in solar module and wind turbine manufacturing sectors is less than 20 percent and 10 percent, respectively. These sectors necessitate a workforce with technical specialisation—from turbine technology in wind manufacturing to electrical component technology in solar module manufacturing.

Trend 5: The bioenergy sectors of biomass to power and CBG require more low-skilled workers

In the case of the biomass to power and CBG sectors, low-skilled workers account for 55 to 60 percent of the total workforce. This is higher than the other decentralized clean energy technologies such as small hydropower and rooftop solar that have less than 50 percent of low-skilled workforce. This is because a majority of the work in the bioenergy sectors revolves around feedstock collection, which has a higher requirement for a low-skilled workforce.

Trend 6: Over the years, the number of jobs created per MW of capacity deployed has reduced in large scale solar and wind

The analysis of the survey data reveals an overall decrease in employment coefficients in the deployment of ground-mounted and wind energy sectors compared to the previous estimates.[37] This decrease can be attributed to several factors that may indicate a gradual maturity of the Indian clean energy industry.

One of the reasons for the efficiency gains is technology improvements. For example, solar module capacities have increased from 300 W to 700 W per panel. Similarly, in wind deployment, the turbine capacities have increased from 2 MW to 3.5 MW, with the largest capacity reaching 5 MW. So, while the size and capacity of the systems have increased significantly, the workforce requirement for the installation phase may remain unchanged.

Further, companies are now working on multiple projects simultaneously due to accelerated annual capacity deployment. As a result, a large number of workers can multitask, with cross-functional job responsibilities, reducing the quantum of dedicated workforce for a project. Hence, the additional direct workforce required for a new project is lower now as compared to previous years when there were fewer number of commissioned projects.

Box 3: Automation in Renewable Energy: Perceived vs. Potential Impact

Progress in the field of artificial intelligence (AI) and robotics is revolutionizing industrial processes as well as day-to-day activities such as transportation, health care, and education.[38] Research indicates that 25 percent of the global capital spending between 2022 and 2027 will be on automation.[39] India recently hosted an AI Impact Summit, signalling its growing ambition to position itself as a global hub for artificial intelligence and digital infrastructure. This momentum is being reinforced by significant investments from global technology giants such as Google, AWS, and others. Such developments are expected to expand India's compute capacity, attract foreign investment, and accelerate AI adoption across sectors. However, existing research on the impact of automation on employment is complex and often inconclusive.[40]

Advanced technologies such as AI, machine learning (ML), and the Internet of Things (IoT) are transforming how grids are managed, systems are maintained proactively, and energy is stored and dispatched. Some of these technologies have also found relevance in the clean energy sectors. Robotic cleaning of solar panels (particularly in utility-scale projects), AI-driven wind turbine diagnostics, biogas plant simulators, and remote monitoring of decentralized renewable energy projects are aiding system performance while reducing the need for human intervention. Beyond improvements in performance, these changes are also reshaping workforce requirements by placing greater emphasis on digital literacy, data analytics, and software-enabled energy management.

Survey questionnaires for this study attempted to assess the influence of automation on job opportunities by analysing the spending on automation-related activities as well as qualitative inputs on the perceived impact of automation on job opportunities. However, the analysis was limited as many respondents could not provide much information on these aspects.

Based on qualitative inputs from the solar and wind deployment sectors, most respondents have not invested in automation yet. The respondents who have invested, or are considering investing, highlighted ML, generative AI, industrial robotics, software automation (e.g., inventory control, HRMS, SAP models), weather control, hybrid automation, and predictive maintenance through ML as possible major areas of investment.

Respondents in the small hydropower and the manufacturing sectors reported investing in automation and software (including Hydro SCADA operations software), fixed and programming automation, battery automation, product automation, precision analytics using big data, product development tools, and online HRM automation

Meanwhile, respondents in the bioenergy deployment sector had not invested in and were not considering investing in automation. There is scope for automation in the biogas manufacturing sector, as newer technologies such as large-scale biogas plant simulations can help achieve higher efficiencies. In the solar water pumps and streetlights sector, major areas of automation include smart water pump controllers, remote monitoring systems, predictive maintenance tools, and automated pump scheduling.

Our survey, initiated in 2024, predates the current explosion of generative AI. The landscape has since shifted dramatically with AI tools now ubiquitous with widespread availability and use cases. While this specific study does not quantify the precise impact of AI and automation on employment, there are growing instances of companies moving towards automation and AI. For example, Adani Green Energy India, uses an Energy Network Operations Centre (ENOC), that uses AI and ML to manage O&M of renewable assets across India, predicting maintenance needs in real time (Adani Renewables).[41] Use of automation in manufacturing is also increasing, for example, Suzlon plans to establish new manufacturing plants that will be entirely digital and AI enabled, along with use of automation and robotics for critical tasks. Companies should focus on optimizing AI use cases and fostering employee adoption to catalyze industry-wide growth.[42]

7. GENDER REPRESENTATION IN THE CLEAN ENERGY WORKFORCE

To reach the government's target of building a 30 trillion-dollar economy by 2047, India will need a workforce with 400 million women. To achieve this target, it has been estimated that the participation rate of women in the workforce needs to increase from its current level of 37 percent to 70 percent.[43] Apart from the obvious economic gains of increasing the total workforce size by increasing women's participation, there are other benefits of a more gender diverse workforce:

- Evidence from India's manufacturing sector underscores the high return on investment of a more inclusive workforce: a 1 percent increase in gender diversity correlates with a 2.9 percent rise in labor productivity and a 2.7 percent boost in total factor productivity.[44]
- An International Finance Corporation survey of banking clients show that women-led small-to-medium enterprises showed better loan performance (crucial for assessing the health of loan portfolios, managing risk, and making informed financial decisions) with lower non-performing loans compared to all small and medium enterprises portfolios for six consecutive years.[45] This is attributed to the finding that women are more likely to diversify supply chains and enable climate-responsive initiatives.

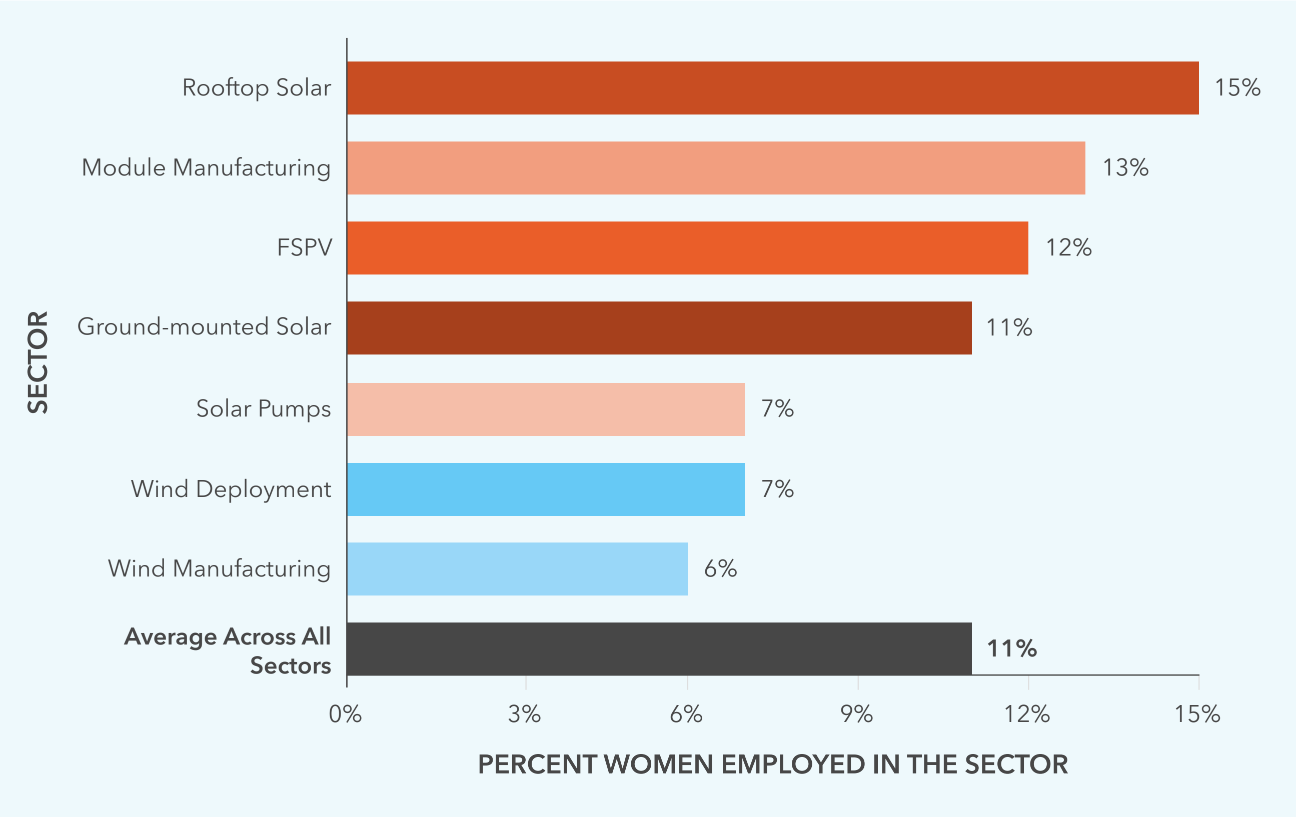
The high return on investment and risk-reduction benefits, associated with greater women participation in the workforce, emphasize the high stakes of reducing the gender gap in the energy transition industry. Consequently, this study aims to evaluate the current level of women's representation in the renewable energy sector. The study assessed the gender representation across the clean energy workforce from multiple perspectives—first, the total number of women in the workforce was assessed; followed by a more detailed understanding of which departments/phases employ more women: technological (such as production and operations) or non-technological (such as HR, accounting, and administration); and lastly, the study analyzed women's participation in leadership roles. Due to the binary nature of the possible responses ('yes' or 'no') to the survey questions, it was difficult to get information for all data points across all sectors. The analysis was thus limited to the ground-mounted solar, floating solar, rooftop solar, module manufacturing, solar pump manufacturing, wind turbine manufacturing, and wind deployment sectors. The following sub-sections discuss the key findings from the analysis of the survey responses.

7.1 Participation of Women in the Active Clean Energy Workforce

Based on the survey, on average, women make up only 11 percent of the total workforce in the solar and wind deployment and manufacturing sectors (Figure 25). While the rooftop solar sector has the highest representation of women (15 percent), the wind manufacturing sector has the least number of women in the workforce (6 percent).

The low participation of women mirrors broader patterns in India's economy. The Periodic Labour Force Survey Annual Report (2023-24) shows a significant gender disparity in workforce participation among India's population (aged 15 years and above). While 78.8 percent of males participate in the labor force, female participation remains substantially lower at 41.7 percent of the working-age women. This gap highlights that fewer than half of working-age women are engaged in the workforce, compared to nearly four out of five men.[46]

Figure 25: Representation of Women in the Workforce Across Clean Energy Sectors



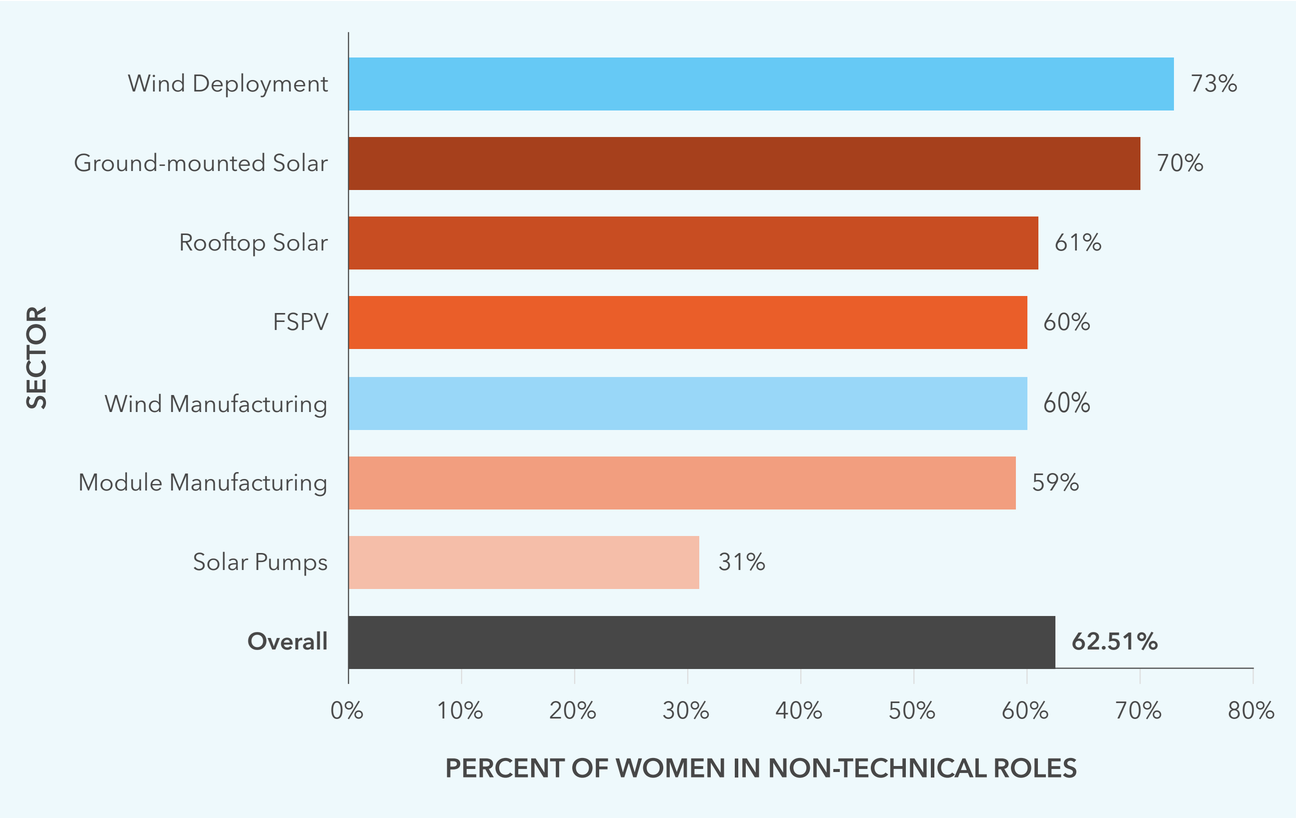
Source: CEEW-NRDC Analysis, 2026

7.2 Job Profiles of Women in the Workforce

More than half of the women workers are involved in non-technological roles such as HR, accounting, administrative, etc. (Figure 26). Non-technological roles are typically office-based roles as compared to on-field, technological roles (such as construction and project operations). The proportion of women in non-technological roles is highest for the wind project deployment (73 percent) and the ground-mounted solar (70 percent) sectors. The solar module manufacturing sector has more gender diversity in the workforce with about 41 percent women employed in technological roles. One of the respondents, within the solar pumps manufacturing sector, was an outlier as more than 81 percent of the women employees in the company were involved in technological roles.

Unfortunately, these trends are in line with broader global patterns. As per a global survey conducted by the International Renewable Energy Agency (IRENA), women are employed in 45 percent of administrative positions but represent only 28 percent of STEM jobs.[47] Similarly, in the study sample for this report, more than 62 percent of the women are involved in non-technological roles.

Figure 26: Representation of Women Workers in Non-technological and Technological Roles Across Clean Energy Sectors



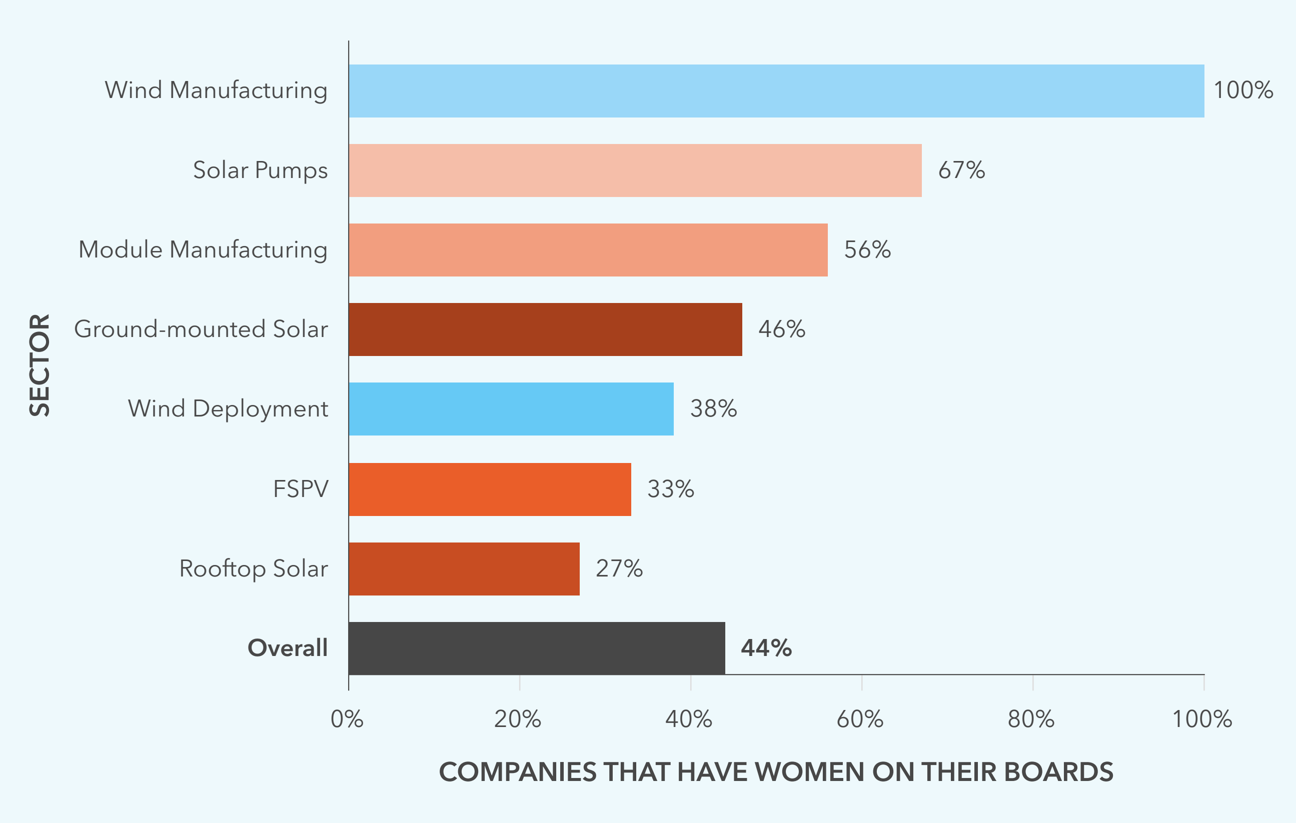
Source: CEEW-NRDC Analysis, 2026

7.3 Women in Positions of Leadership

The study also assessed the presence of women on the boards of clean energy sector companies to understand how women are represented in leadership roles across sectors. It should be noted that this information was unavailable for the biomass to power, CBG, and hydropower sectors.

Of the companies in the study sample, about 44 percent had at least one woman on their board (Figure 27). Rooftop solar sector had the lowest proportion (approximately 27 percent) of companies with at least one woman on the board. The one company surveyed in the wind manufacturing sector also had a woman on their company's board.

Figure 27: Representation of Women in Leadership Roles Across Clean Energy Sectors



Note: Wind manufacturing includes data from one company only

Source: CEEW-NRDC Analysis, 2026

While the number of women pursuing STEM degrees is increasing in India, women's participation in the STEM workforce remains low.[48] The low participation of women in the clean energy workforce can be attributed to multiple reasons, some of which are not limited to these sectors and are part of larger systemic and societal barriers. Based on stakeholder discussions with human resources professionals in the solar and wind sectors, some of the possible reasons for the low representation of women in these sectors include:

- Burden of additional responsibilities, such as child and family caregiving, that limit the job options available for women both in terms of location as well as working hours.
- Lack of supporting environment at workplace for women with children—such as day care and flexible working hours—that leads to high attrition rates.

These issues get more pronounced due to the dynamics of the renewable energy industry. For instance, most of the large-scale ground-mounted solar and wind projects are located in remote locations with poor connectivity and sparse habitation. From the perspective of a woman in the workforce, they are apprehensive of working in such areas due to safety and security concerns. Unfortunately, some of the employers may view employing and retaining women in such remote work locations as an additional economic burden (as more women in the workforce necessitates additional amenities and infrastructure, such as enhanced security at the workplace). Such an increase in project costs often conflicts with investor expectations of returns despite their desire for diversity. Companies which had a higher share of women in the workforce mentioned that gender diversity was a mandate from their investors. While this is true for deployment sectors, it is not the case for jobs in the manufacturing sectors since these are centralized jobs in factories or facilities, making manufacturing a key area to encourage women's participation.

Some companies reported implementing dedicated initiatives to increase women's participation, but these efforts were limited in their scope and impact. Such efforts typically involved either reserving certain job positions for women or giving preference to women in specific roles or setting internal targets to boost participation of women in the workforce. However, these reserved jobs were usually for non-technical roles.

These insights indicate that the under-representation of women in the clean energy workforce is constrained due to systemic barriers, preventing women from entering and contributing in the workforce. A promising attribute, however, is the increased investments from foreign players in the clean energy sectors, which usually tend to drive inclusivity and diversity in the workforce.[49]

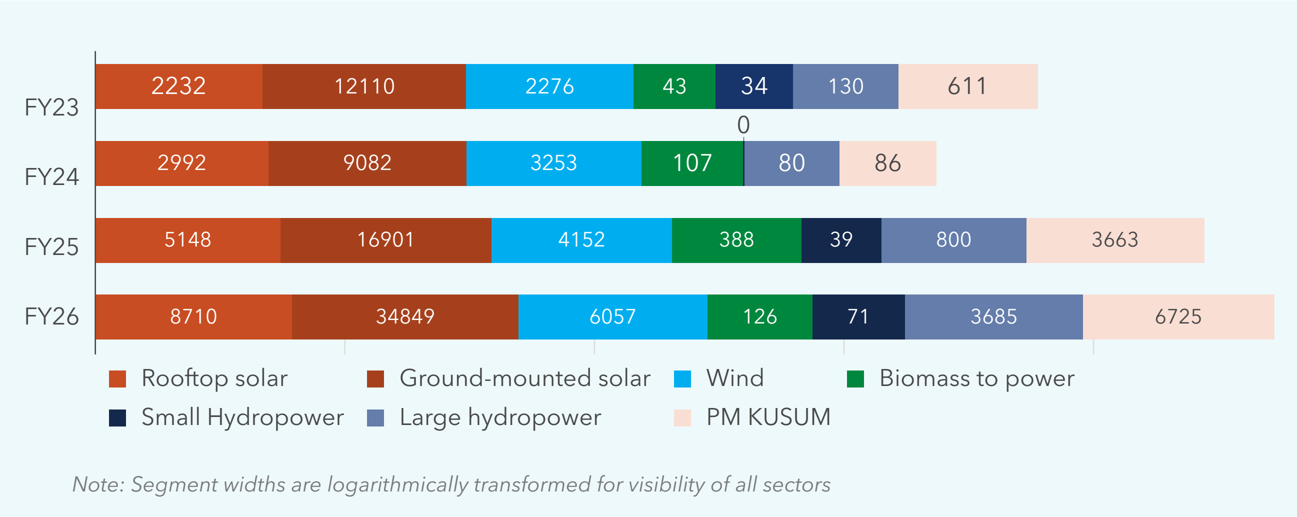
Despite low representation of women in the renewable energy sector, the decentralized renewable energy sector delivers some important benefits to women. For example, biogas plants empower rural women by converting cattle dung and organic waste into clean cooking gas and organic fertilizer, saving hours of daily labor in firewood collection. Additionally, evidence from a study spanning 18 states suggests that decentralized renewable energy technologies—including solar-powered silk reelers and refrigerators—have improved incomes for nearly 90 percent of users. For women in particular, the benefits extend beyond financial gains, encompassing greater agency, enhanced knowledge and skills, increased mobility, and more active participation in community and social life.[50] Decentralised renewables thus offer significant livelihood and wider socio-economic benefits for women.

8. WORKFORCE ADDED FROM RENEWABLE ENERGY INSTALLATIONS IN THE PAST FOUR YEARS

The study used sector-specific FTE coefficients to estimate the workforce added in the clean energy sectors over the last four financial years (FY). As the FTEs are developed based on the projects commissioned in the same timeframe, they can be applied with accuracy to estimate workforce additions. It should be noted that due to the constraints around the availability of annual capacity for some sectors, the study has focused only on assessing the workforce added in select sectors—the deployment of rooftop solar, ground-mounted solar, and wind sectors. For solar module and wind turbine manufacturing, only the total workforce has been calculated, as there was a lack of data on annual additions to manufacturing.

Between FY23 and FY26, India deployed approximately 19,000 MW (19 GW) of rooftop solar capacity. Around 45 percent of the added capacity was deployed in 2025-26. This can be attributed to the 'PM Surya Ghar: Muft Bijli Yojana', the Government of India's rooftop solar initiative introduced in February 2024, which provides a subsidy for rooftop solar installations in the residential sector.[51] The ground-mounted solar sector also witnessed impressive growth with more than 72,000 MW (72 GW) capacity added in the last four financial years. Wind deployment, on the other hand, witnessed comparatively slower growth with a little more than 15,000 MW (15 GW) capacity added in the last four financial years. Figure 28 summarizes these clean energy deployment trends for FY23 to FY26.[52]

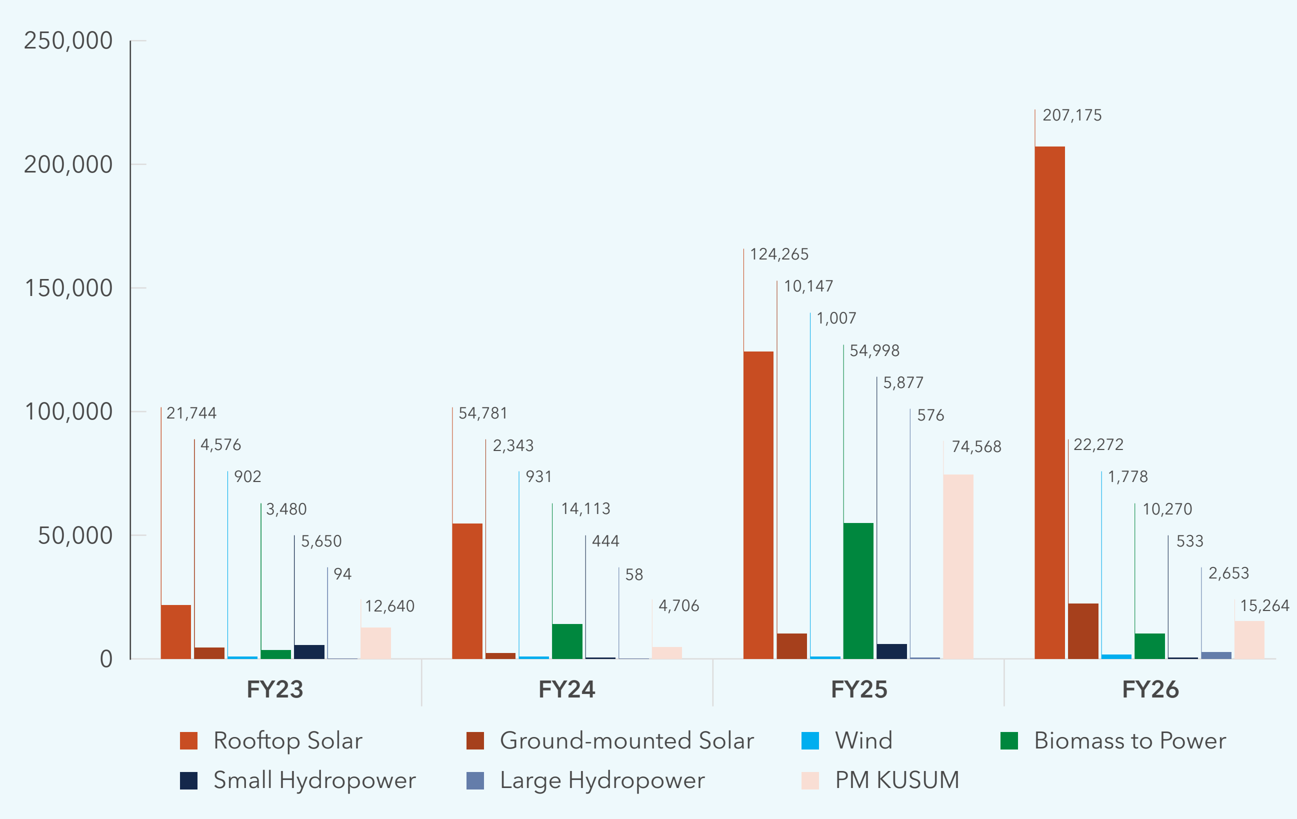
Figure 28: Annual Clean Energy Capacity Deployment Trends (FY23 to FY26)



Source: CEEW-NRDC Analysis, 2026

Based on these capacity deployment trends, the study estimated the workforce added to these sectors. Between FY23 and FY26, the sectors added approximately 6.5 lakh (657,845) workforce. 62 percent of the new workforce added were in the rooftop solar sector, followed by jobs added through the PM-KUSUM scheme, which accounted for approximately 16 percent of the additional workforce (Figure 30).

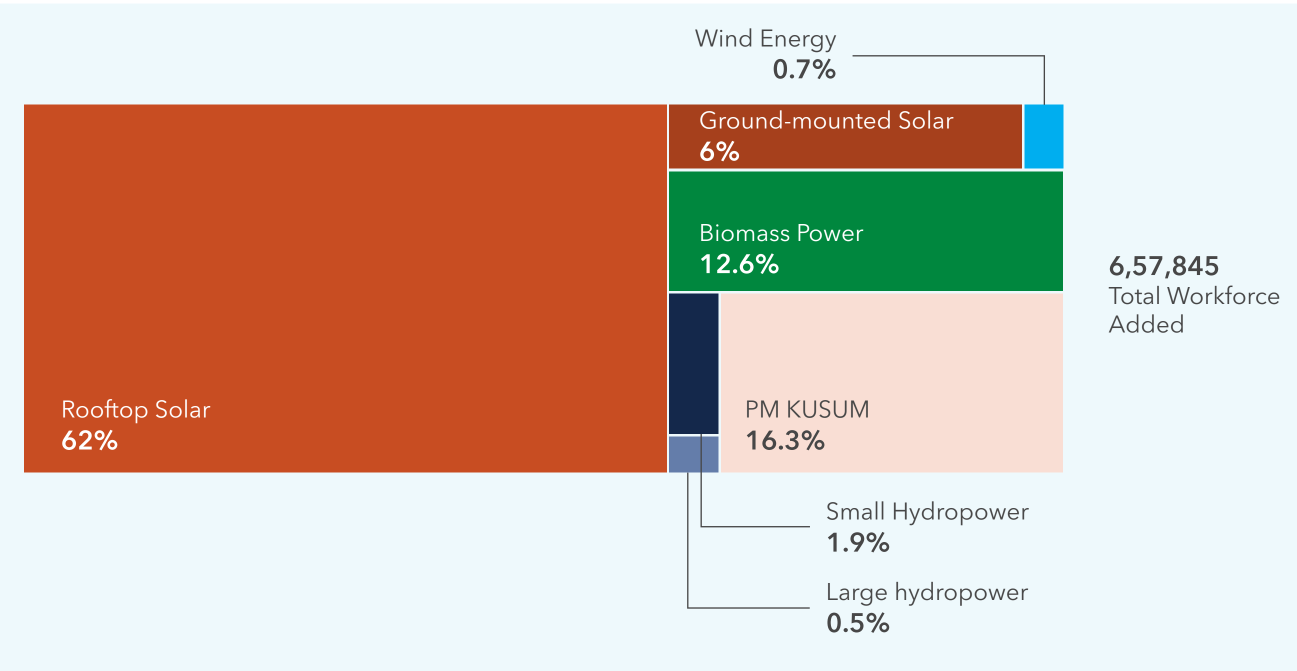
Figure 29: Distribution of Workforce Added Across Clean Energy Sectors (FY23 to FY26)



Source: CEEW-NRDC Analysis, 2026

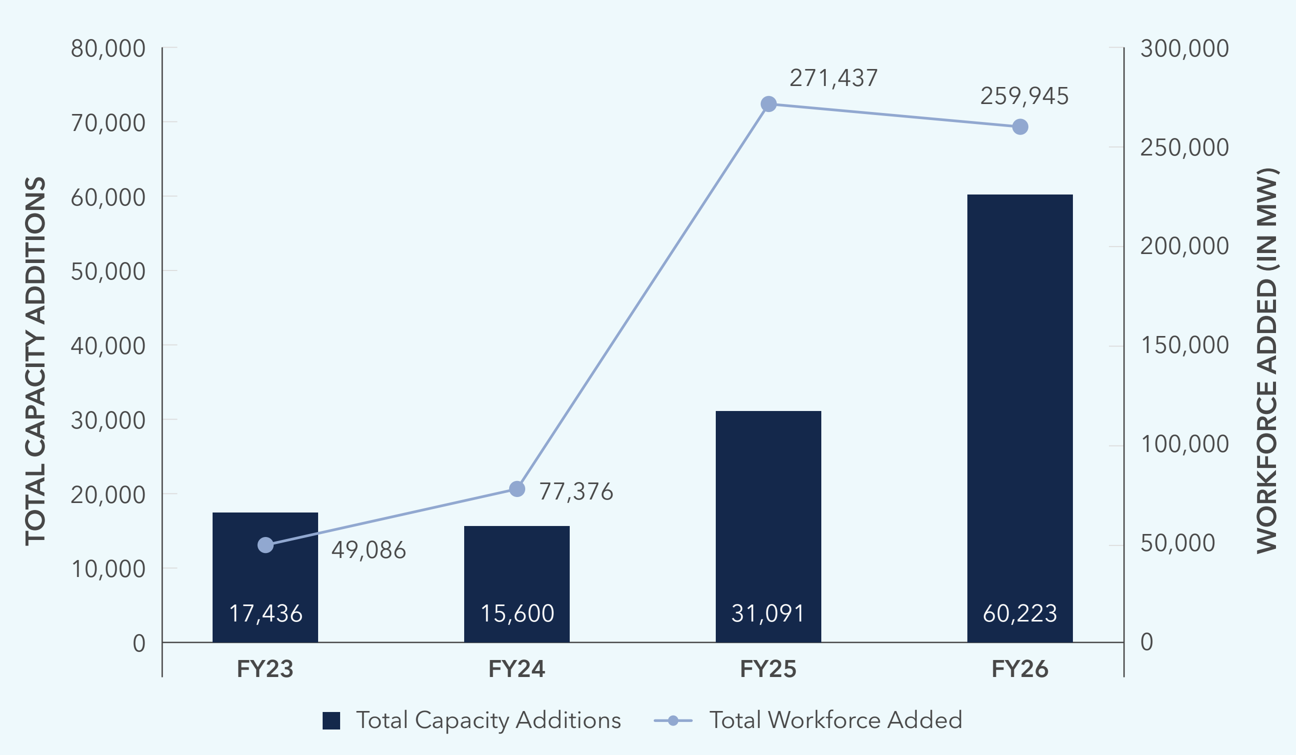
The immense scale of capacity deployment in FY25, when about 31 GW of capacity was deployed, led to the highest annual workforce addition as approximately 2.7 lakh (270,000) workers were added to the clean energy sectors (Figures 29-31). Around 46 percent (124,265 workforce) of the clean energy workforce added in FY25 were in the rooftop solar sector, driven by about 5.1 GW of capacity deployment.

Figure 30: Sector-wise Distribution of Workforce Added



Source: CEEW-NRDC Analysis, 2026

Figure 31: Annual Capacity Additions and Corresponding Annual Workforce Additions (FY23 to FY26)



Source: CEEW-NRDC Analysis, 2026

The total workforce was also calculated for the solar module manufacturing and wind turbine manufacturing sectors (not added in the figures, as the other sectors are deployment centric). As of FY2026, the solar module manufacturing sector had a production capacity of approximately 150 GW which amounts to a total workforce of approximately 226,500. [53] The wind manufacturing sector currently has an installed capacity of 18 GW, which employs approx. 25,920 workers.[54]

While deployment sectors are creating employment, the issues of lack of trained workers and skills shortages persist. Consultations with companies in the sector reveals that companies are struggling to find sector-specific trained workers, while various training institutes have low placement rates. This can be attributed to the lack of practical, hands-on field training as part of program curricula, lack of familiarity with new technologies and others.[55]

The study focuses on the quantum of employment rather than the quality of labor. For example, in the biomass sector, high employment figures coexist with significantly lower capacity deployment as compared to large solar or wind projects. This suggests a lower labor efficiency, where jobs result in lower capacity installed. Future research is required to evaluate the total factor productivity of these roles to avoid the misconception that investment in sectors naturally yields high-value economic returns.

9. ESTIMATE OF JOBS GENERATED IN ACHIEVING INDIA'S NATIONAL CLEAN ENERGY TARGETS

India's target of 500 GW of non-fossil fuel capacity (including nuclear) and goals under the National Green Hydrogen Mission are projected to generate more than 44 lakh (4.4 million) FTE jobs. Renewable energy sectors analyzed as part of this study–wind, ground-mounted solar, solar pumps, rooftop solar, small and large hydropower, biomass, solar module, and wind turbine manufacturing– are estimated to create more than 41 lakh (4.1 million) FTE jobs. Of these, approximately 12.8 lakh (1.28 million) FTE jobs are expected to be under the operations and maintenance and manufacturing phases which are sustained over the lifetime of the project and plant (Annexure 4).

Table 11: Estimate of Jobs Generated in Achieving India's National Clean Energy Targets

RE Sector	Target (GW)*	New FTE Coefficients (Job-years/MW)	Overall Estimated Workforce Generation**
Wind Energy	99.9	0.65	91,361
Ground-mounted Solar Energy and Offgrid	217.2	1.00	3,59,062
Solar Projects under PM-KUSUM: Component A***	10	1.17	11,650
Solar Projects under PM-KUSUM: Component B****	7	47.91	3,35,356
Solar Projects under PM-KUSUM: Component C Grid Connected Pumps^	1.1	47.32	52,052
Solar Projects under PM-KUSUM: Component C Feeder Level Solarization***	16.7	1.17	19,455
Rooftop Solar (<10 KW)^^	40.0	54.91	19,28,497
Small Hydropower	5.62	152.43	1,71,627
Large Hydropower (O&M phase only)^^^	53.9	0.72	38,779
Biomass to Power	14.5	164.82	8,67,247
Solar Module Manufacturing	150.0	1.5	2,26,500
Wind Manufacturing	25.0	1.4	36,000

RE Sector	Target (GW)*	New FTE Coefficients (Job-years/MW)	Overall Estimated Workforce Generation**
Nuclear (not included in this study)^^^^	15.0	1.60	24,000
Hydrogen Production—National Green Hydrogen Mission (not included in this study)^^^^	5 MMT^^^^^	-	2,95,133
Total			**44,56,719**

Notes:

**Targets are as per the Ministry of New and Renewable Energy (2024) and the Ministry of Power (2023). For solar and wind manufacturing and PM-KUSUM sectors, targets are as per discussions with MNRE officials. For PM-KUSUM, capacities likely to be achieved against the commissioned ones are used.*

*** For capacities deployed until March 2023, FTE are taken from Tyagi et al 2022.[56] For capacities installed post March 2023, to achieve the cumulative target, new FTEs mentioned in column 3 of the table have been used.*

****Ground-mounted Solar FTE (for smaller systems below 2 to 3 MW) used as scheme targets smaller sized systems.*

***** Rooftop Solar FTE for 5 kW systems along with solar pumps systems installation FTE have been used*

^ Rooftop solar FTE for 5 kW systems have been used.

^^ FTE of 1 to 10 kW systems have been used as scheme is targeted toward systems of 1 to 10 kW under PM Surya Ghar Yojana.

^^^ FTE includes only power generation and maintenance phases.

^^^^ FTEs, targets, and jobs have been taken from the MNRE Report, 2024, and are not from this study as these sectors are not included in this study.

^^^^^ MMT: Million Metric Tons

Source: CEEW-NRDC Analysis, 2026, and analysis of Ministry of New and Renewable Energy 2024[57]

10. LIMITATIONS OF THE STUDY

Identifying and acknowledging limitations is important to ensure an accurate interpretation of the results and to facilitate future research or improvements in studies. These are some of the notable limitations of the study:

a. **Lack of information on market size to assign weights to sample data while calculating FTEs:** Due to unavailability of adequate market size data, sector-wise calculations of FTE employment coefficients relied on simple averages (instead of weighted averages) that treats data from all survey respondents equally, regardless of company size or market share. Such a methodology potentially misrepresents sectors where employment is concentrated among a few major players.

b. **Low number of responses:** While the survey was designed to collect more data across sectors, however, it received fewer responses than anticipated. A larger sample size would have helped to further substantiate the industry-wide workforce estimates. To address this limitation, the report presents many of the estimates as case studies.

c. **Lack of standardized reporting practices across organizations:** There is a discrepancy in reporting practices as some organisations provided information based on their existing database systems, while others provided data based on recollections only.

d. **Analysis timelines:** The survey for the study was conducted from March 2024 to December 2025. Hence, the FTEs are calculated based on data received and not to date. FTE coefficients and workforce numbers do not consider any recent developments in the sector.

e. **Subjective decisions about skill levels classification:** Skill levels are defined by a combination of assessment factors such as educational backgrounds, complexity of work, and knowledge. While the survey included these definitions of skills levels, respondents made classifications based on broad estimates rather than evaluating individual workers by worker competencies and roles.

f. **Degree of automation, scale of businesses, and business models (vertical/horizontal integration) vary across companies and is not considered:** Companies in the study sample have varying levels of automation and efficacies. These have not been integrated as part of the study.

11. CONCLUSION AND RECOMMENDATIONS

This study focused on estimating direct employment in India's core clean energy sectors. Future research should expand to include supporting industries and indirect jobs—such as manufacturing inverters and mounting structures, community-based roles in decentralized energy projects, and last-mile clean energy services—to capture the full employment impact of the clean energy value chain. Additionally, based on the analysis presented in this report, the following action points are recommended:

1. **MNRE, and the related institutions, should institutionalize workforce reporting as part of existing processes related to renewable energy projects.** Currently, various government entities (including MNRE, SECI, NISE, and others) collect a range of information from clean energy companies during different project stages such as process of tender selection, awarding of subsidies and incentives, audits, etc.. Mandatory reporting of workforce numbers can thus be embedded in these existing processes. A standard template should be used to collect data on workforce requirements and gender representation in both the general workforce and leadership roles.
2. **Clean energy companies should undertake a proactive approach towards gender inclusivity to tap into underutilized talent and enhance business performance.** Gender representation remains a critical but under-addressed aspect of India's clean energy transition. This must be anchored in principles of equity, requiring targeted interventions to recruit, retain, and build capacities to advance women's contribution across the sector. **Companies must move beyond basic hiring mandates to actively employ women in leadership, technological, and entrepreneurial roles** and not just in traditionally gendered administrative or support roles. This requires comprehensive action across multiple areas—such as ensuring workplace safety provisions; mentorship opportunities; designing sector-specific gender-responsive skill building programs (such as offering alternative delivery methods like online-offline hybrid formats); earmarking certain percentage of leadership positions for women; and, flexible work arrangements with evolving job needs.
3. **Clean energy companies and training institutes should focus on creating career advancement programs for the existing workforce.** The study shows that there is a high requirement of semi- and highly-skilled workforce, especially in the solar and wind manufacturing sector. There is an opportunity for the solar and wind industry to develop career advancement programs that are focused on providing training to their existing workforce to help them upskill from low-skilled to semi-skilled roles or from semi- to highly-skilled roles. This can be achieved by incorporating a culture of continuous learning, partnering with experts to deliver technical training and mentorship, etc. Training institutes can also play an important role by embedding these initiatives (by the clean energy companies) among the trainees and mentoring them for a long career.
4. **MNRE, along with NSDC and training institutes, should strengthen monitoring and evaluation of skill building initiatives.** Stakeholder consultations and feedback underscored the need for timely assessment of the quality and relevance of clean energy skill building and training initiatives to effectively meet industry needs and requirement for practical, on-ground training. The MNRE—along with the National Skill Development Corporation (NSDC), other sector skill councils, and the dedicated training institutes—should conduct annual performance reviews

of their training programs via regular information exchange and closer collaboration with clean energy companies to stay up-to-date with changing industry requirements. Additionally, MNRE and NSDC should evaluate the performance of current mechanisms to include private sector in the skill building ecosystem.

India's clean energy sector is poised for considerable growth, with strong commitments from the government and industry to scale up the clean energy capacity. Alongside environmental benefits, this transition is expected to create sustainable employment opportunities across various segments of the sector. However, evolving technologies, automation, and efficiency improvements are reshaping workforce requirements. These technological advancements and changes are leading to a shift in the nature and intensity of clean energy jobs by reducing the labor intensity of certain roles while generating demand for new, highly-skilled jobs. As India continues its journey toward becoming a Viksit Bharat, it is imperative to ensure that the renewable energy employment ecosystem remains inclusive, adaptive, and future-ready.

Image source: iStock

ANNEXURES

Annexure 1: Comparison of Global Studies on Clean Energy Employment

Geographic Coverage	U.S. Department Of Energy's Energy & Employment Report, 2023[58]	IRENA's Renewable Energy and Jobs–Annual Review 2026[59]	Global Jobs Analysis, 2015[60]	Renewable Energy Employment in Australia, 2020[61]	India's Clean Energy Sectors Jobs Analysis, 2025 (current report)
	United States	**Global**	**Global (divided into 9 regions)**	**Australia**	**India**
Organizations Involved/Led by	U.S. DoE, Bureau of Labor Statistics, BW Research	IRENA	Institute for Sustainable Futures at University of Technology, Sydney, for Greenpeace International	Institute for Sustainable Futures at University of Technology, Sydney	NRDC and CEEW, with support and guidance from the Ministry of New and Renewable Energy, Government of India
Scope	Examines establishments that work with energy-related technologies (large scope)	(not available)	Almost lifetime scope–manufacturing until disposal	Mainly focused on the implementation phase of RE sectors (operation, construction, maintenance)	Large scope–across different phases of deployment and manufacturing of RE sectors
Sectors Included	The report includes 266 industries, including clean energy sectors, using the six-digit North American Industry Classification System (NAICS) codes	Renewable energy employment–solar photovoltaic, bioenergy, wind energy, solar heating/cooling, hydropower, geothermal energy, concentrated solar power, heat pumps (ground-based), municipal and industrial waste, and ocean energy	Manufacturing, construction and installation, operations and maintenance, fuel supply associated with electricity generation, decommissioning of power plants at the end of their lifetimes, and transmission	Large-scale solar and wind energy, on-site solar PV and solar hot water at residential, commercial and industrial sites, hydro generation and storage, battery storage, supply chain for these technologies bioenergy, renewable hydrogen, professional services (government, research and development, consultancies etc), electricity networks construction and operation, electricity retailing	Renewable energy deployment sectors (solar, wind, CBG, and large hydropower) and manufacturing sectors (solar modules, wind turbines, solar pumps)

Geographic Coverage	U.S. Department Of Energy's Energy & Employment Report, 2023[58]	IRENA's Renewable Energy and Jobs–Annual Review 2026[59]	Global Jobs Analysis, 2015[60]	Renewable Energy Employment in Australia, 2020[61]	India's Clean Energy Sectors Jobs Analysis, 2025 (current report)
	United States	**Global**	**Global (divided into 9 regions)**	**Australia**	**India**
Types of Jobs Assessed (Direct, Indirect, Induced)	Direct jobs	Both direct and indirect jobs	Direct jobs	Both direct and indirect jobs	Direct jobs
Data Sources	United States Energy & Employment Report (USEER) 2023 Survey, BW research survey, Bureau of Labor Statistics	National level surveys for different countries (ex: China Heat Pump Alliance report, U.S. Department of Energy survey)	National level reports and studies on modelling employment, energy and fuel statistics, and energy systems	National energy reports, industry reports, and data from clean energy organizations	Survey agency selected by NRDC and CEEW
Approach and Methodology	Workforce calculated by identifying the proportion of energy-related companies and proportion of workers that engage in the sector Commodity flow calculations are used to identify workforce in sectors such as the flow of transportation	Employment-factor approach, Supply-chain approach, Input-output models used for calculating workforce	Workforce is calculated using Employment-factor approach for each industry–manufacturing for local use and export, construction, operations and maintenance, fuel, and heat supply	Workforce is calculated using Employment-factor approach for manufacturing, construction, operations and maintenance employment annually	Workforce is calculated using Full-Time Equivalent employment coefficients across business phases separately for all the sectors analyzed (refer to the methodology section for more details)

Source: Authors' analysis of studies mentioned

Annexure 2: Survey Questionnaire for Biomass Developer

Section A - Respondents detail

Q.1. Name of the Company:

Q.2. Please enter the details of the respondent

a. Name:

b. Designation:

c. Email ID:

d. Contact Number:

Section B - Company profile

Q.3. Please select the option(s) that describe the key role of your organization in Biomass sector (Multiple selections possible)

• Plant owner/operator	
• Engineering, Procurement and Construction (EPC) Contractor	
• Turnkey Solutions Provider	
• Non-EPC Service Company / Consultancy	
• Other (Please specify in comments below)	

Q.4. Please select the turnkey service(s) provided by your company in Biomass segment (Multiple selections possible)

• Advisory Services (Legal, Subsidy, Financing, PPAs etc.) and Approvals	
• Project Financing	
• Project Management	
• Asset management	
• Site Survey and Feasibility Study	
• Plant Commissioning	
• Operations and Maintenance	
• Other (Please specify in comments below)	

Q.5. If non-EPC Service Company / Consultancy, please mention the services provided by your company.

Q.6. What is the total capacity commissioned under management (in MW) by your organization in the following years?

Year	Commissioned capacity (MW)
FY20	
FY21	
FY22	
FY23	

Q.7. What is the planned addition in the total commissioned capacity (in MW) by your organization for the following years?

Year	Commissioned capacity (MW)
FY24	
FY25	
FY26	

Section C - Organization level information

Q.8. What is the total number of staff or consultants employed by your organization?

Ans.:

Q.9. What is the expected percentage increase/decrease in the total number of staff employed by your organization in the coming year?

Ans.:

Q.10. What is the total number of women (staff or consultants) employed by your organization?

Ans.:

Q.11. What is the highest level of female employee in your organization?

Ans.:

Q.12 .What percentage of leadership are women?

Ans.:

Q.13. What percentage are in senior management and middle management?

Ans.:

Q.14. Do you have women representation on your board?

Ans.:

Q.15. Are their initiatives specifically targeted at increasing women's representation? If yes, please share details?

Ans.:

Q.16. What percentage of women are in non-technical roles (such as HR, finance, admin, communications)?

Ans.:

Section D - Project Specific Detail

Q.17. Please enter the following details about a Biomass energy project by your organization, preferably one that has been recently completed.

• Name of Project:	
• Location of Project:	
• Commissioning Date:	
• Size of Project (MW):	
• Primary feedstock:	
• Secondary feedstocks, if any	
• No. of operational days	

Q.18. What would best describe the technology and output of your plant?

a. Bagasse-based biomass power plant

b. Non-bagasse biomass power plant (can include other agricultural and forestry residue)

c. Biomass-based steam generation plant

d. Others (please mention)

Q.19. Can you please mention your operating model?

a. Captive plant (please mention primary industry)

b. Independent energy producer (please mention off-taker industry)

c. Others (please mention)

Q.20. Are you aware of the total workforce involved on the project including those from other organizations including EPC, turnkey solution provider, manufacturer etc.?

a. Yes

b. No

Q.21. Will you be able to provide total employment associated with each phase from all organizations?

a. Will you be able to provide total employment associated with each phase from all organizations?

b. No, I am providing information for my organization

Q.22. Please provide the answers to following question associated to of Biomass value chain.

S. No	Question	Business Development Phase	Design and Pre-construction Phase	Construction and Commissioning Phase	Operations and Maintenance Phase
22.a	Total duration of the phase				
22.b	Total number of employees working in this phase				
22.c	Number of people employed in each category as per skill level[62]				
	High				
	Semi-skilled				
	Low-skilled				
22.d	Share of women employees in the total strength in this phase (%)				
22.e	Do people involved in this phase work on multiple projects? If yes, how many projects, on average, do people get involved with?				
22.f	In line of above response, on average, in the each phase, how much time does an employee give to this project? Please answer in % time dedication (Ex. On average, for an employee working on multiple projects simultaneously, 20 % of the time is solely dedicated to this project).				

Q.23. Do you have a detailed workforce roster for the project?

a. Yes

b. No

Q.24. If yes, can you share it with us?

a. Yes

b. No

Q.25. Do you have an estimate of how many additional jobs were supported by this project (during or post construction)? (If yes, please share the number and type of jobs)

a. Yes

b. No

Section E- Skills

Q.26. What are the top five skills in demand for your sector?

Department	Skills
Business Development	
Design & Pre-Construction	
Construction & Commissioning	
Operation & Maintenance	

Q.27. What are the top five skills lacking in your sector?

Business Development	
Design & Pre-Construction	
Construction & Commissioning	
Operation & Maintenance	

Section F – Automation

Is your company planning to invest in automation? If yes, **please** answer the following questions.

1. What technologies is the company planning to invest in?

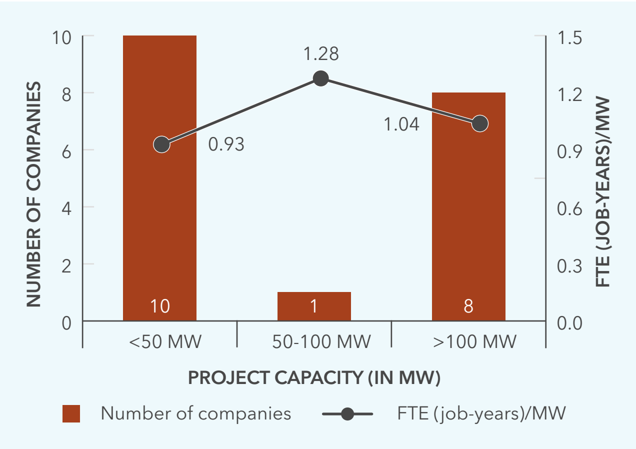
2. Which phase or corporate function would this be deployed in?

3. What would be the impact of automation on employment (increase, decrease, stay the same)?

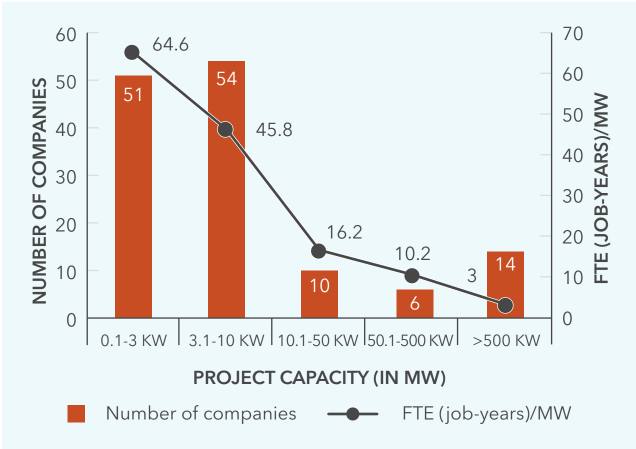
Annexure 3: Project/Plant Size-wise Distribution of Projects Across Clean Energy Sectors

FTE (job-years)/MW along with Number of Companies.

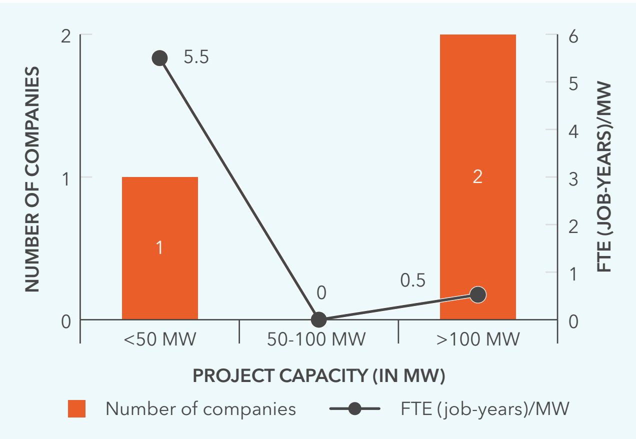
Ground mounted solar



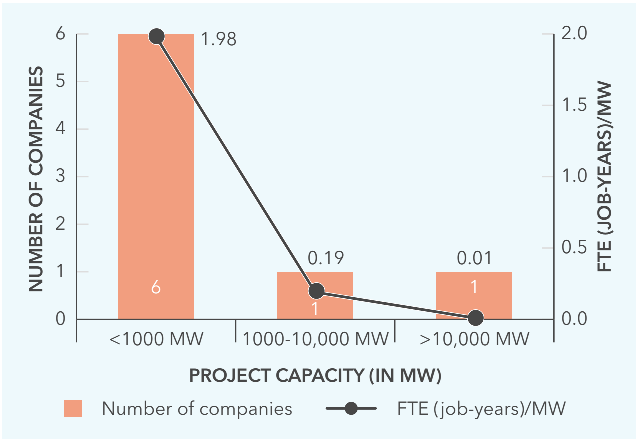
Rooftop solar



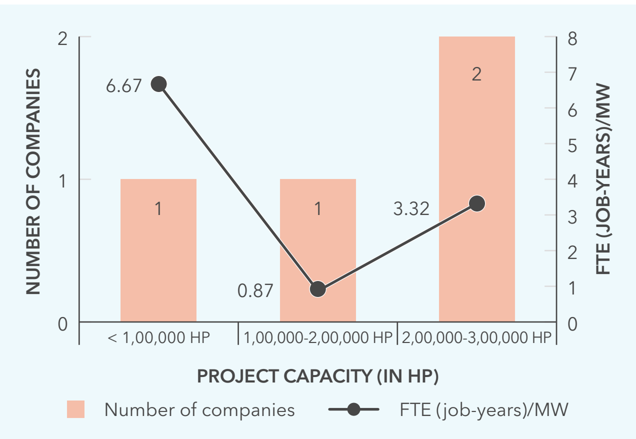
Floating solar



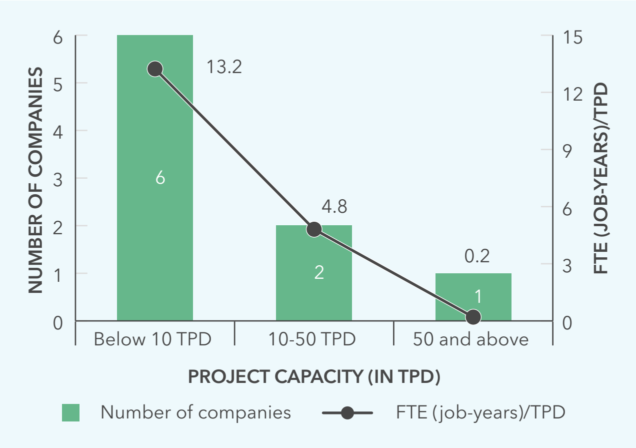
Module manufacturing



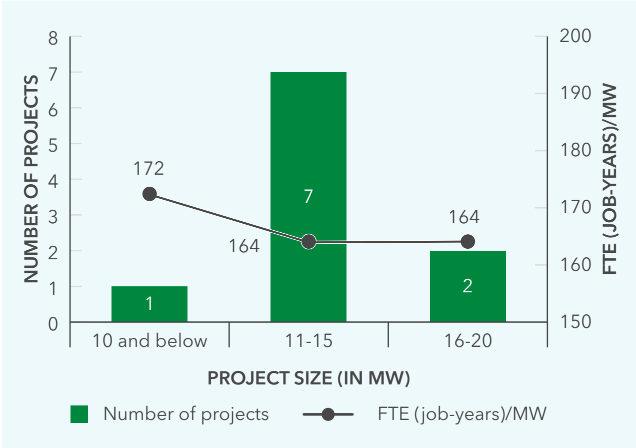
Solar pump manufacturing



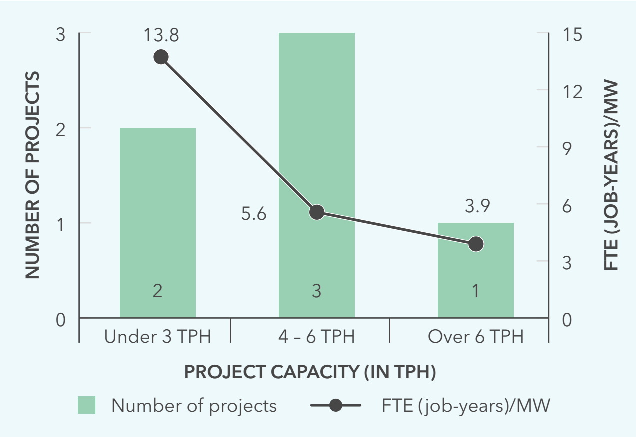
Compressed biogas



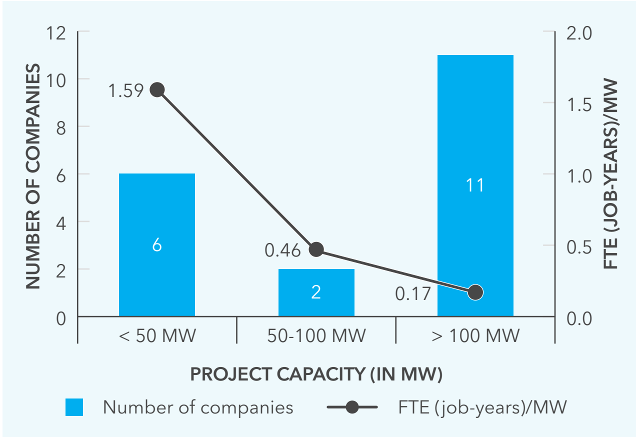
Biomass to power



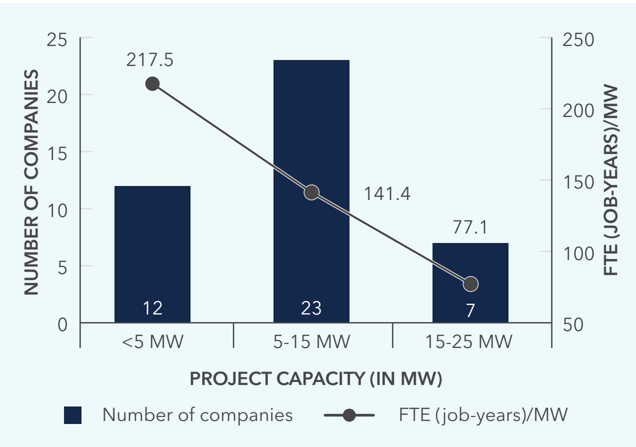
Pellet manufacturing



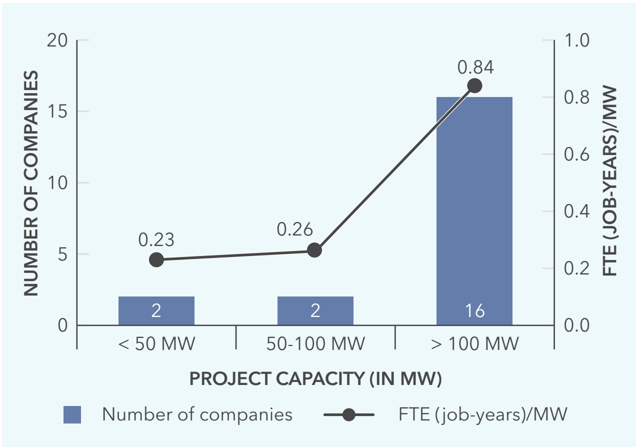
Wind



Small hydropower



Large hydropower



Annexure 4: Estimated Jobs in O&M and/or Manufacturing

RE Sector	RE Jobs Generated		
	Jobs in BD, Design, and Construction	Jobs in O&M and/or Manufacturing	Total Jobs
Wind Energy	62,601	28,760	91,361
Utility-scale Solar Energy and Off-grid	2,88,694	70,369	3,59,062
PM-KUSUM Component A (<3 MW)	9,640	2,010	11,650
PM-KUSUM Component B	2,74,995	60,361	3,35,356
PM-KUSUM Component C IPS (0-5 KW)	42,570	9,482	52,052
PM-KUSUM Component C FLS (0-5 KW)	16,099	3,357	19,455
Rooftop Solar (0-10 KW)	15,69,723	3,58,774	19,28,497
Small Hydropower	1,62,376	9,251	1,71,627
Large Hydropower*		38,779	38,779
Biomass to Power	4,25,733	4,41,514	8,67,247
Solar module manufacturing		226500	226500
Wind Manufacturing		36,000	36,000
Total	**28,52,430**	**12,85,156**	**41,37,586**

Note:

** No FTE coefficient developed for phases prior to O&M*

Source: CEEW-NRDC Analysis 2026

REFERENCES

1 Ministry of New and Renewable Energy (Government of India), " India Ranks third globally in Renewable Energy Installed Capacity: Shri Pralhad Joshi," April 08, 2026, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2250039&reg=3&lang=1.

2 Ministry of New and Renewable Energy (Government of India), "India's Renewable Rise: Non-Fossil Sources Now Power Half the Nation's Grid," July 14, 2025, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2144627.

3 "Belém COP30 delivers climate finance boost and a pledge to plan fossil fuel transition," *UN News*, November 22, 2025, https://news.un.org/en/story/2025/11/1166433.

4 Hemant Mallya, Deepak Yadav, Anushka Maheshwari, Nitin Bassi, and Prerna Prabhakar, *Unlocking India's RE and Green Hydrogen Potential: An Assessment of Land, Water, and Climate Nexus*, Council on Energy, Environment and Water (CEEW), September 2024, https://www.ceew.in/sites/default/files/renewable-energy-green-hydrogen-lands-water-nexus-in-india.pdf.

5 International Energy Agency, *World Energy Employment, August 2022*, https://iea.blob.core.windows.net/assets/a0432c97-14af-4fc7-b3bf-c409fb7e4ab8/WorldEnergyEmployment.pdf.

6 Akanksha Tyagi et al., *India's Expanding Clean Energy Workforce: Opportunities in the Solar and Wind Energy Sectors* Council on Energy, Environment and Water (CEEW), Natural Resources Defense Council (NRDC), and Skill Council for Green Jobs (SCGJ), January 2022, https://www.nrdc.org/sites/default/files/indias-clean-energy-workforce-450-gw-target-report.pdf.

7 Neeraj Kuldeep, Kanika Chawla, Arunabha Ghosh, Anjali Jaiswal, Nehmat Kaur, Sameer Kwatra, Karan Chouksey, *Greening India's Workforce: Gearing Up for Expansion of Solar and Wind Power in India*, CEEW and NRDC, June 2017, https://www.ceew.in/sites/default/files/CEEW-NRDC-Greening-India-Workforce-report-20Jun17.pdf.

8 Data on modules from: Grid Solar Power Division, Ministry of New and Renewable Energy (Government of India), *Approved Models and Manufacturers of Solar Photovoltaic Modules* (Requirements for Compulsory Registration) Order 2019, updated June 5, 2025, https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2025/06/202506061315987137.pdf.

9 Data on Hydropower from: Ministry of New and Renewable Energy (Government of India), "Approved List of Models and Manufacturers (ALMM)," n.d., https://mnre.gov.in/en/approved-list-of-models-and-manufacturers-almm/.

10 Date on Large Hydropower from: Central Electricity Authority, Ministry of Power (Government of India), *Review of Performance of Hydro Power Stations* 2023-24, February 2025, https://cea.nic.in/wp-content/uploads/annual_hydro/2024/Hydro_Performance_Review_Report_2023_24_Approved.pdf.

11 Department of Economic Affairs, Ministry of Finance (Government of India), *Notification of the National Skill Qualification Framework (NSQF)*, December 27, 2013, https://www.nqr.gov.in/sites/default/files/NSQF%20Gazette%20Notification.pdf.

12 Ministry of New and Renewable Energy (Government of India), *Renewable Energy Statistics 2024-25*, November 2025, p. 45, https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2025/11/202511061627678782.pdf.

13 Ministry of New and Renewable Energy (Government of India) and National Institute of *Solar Energy, Solar PV Potential of India: Ground Mounted, September 2025*, https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2025/09/2025091759291579.pdf.

14 Hemant Mallya, Deepak Yadav, Anushka Maheshwari, Nitin Bassi, and Prerna Prabhakar, *Unlocking India's RE and Green Hydrogen Potential: An Assessment of Land, Water, and Climate Nexus*, CEEW, September 2024, https://www.ceew.in/sites/default/files/renewable-energy-green-hydrogen-lands-water-nexus-in-india.pdf.

15 Ministry of New and Renewable Energy (Government of India), "Year wise Achievements: Installed Renewable Energy Capacity(MW) (Excluding Large Hydro Power)," accessed on June 2, 2025, https://mnre.gov.in/en/year-wise-achievement/.

16 Surrounding parameters such as dust (that impacts soiling on panels), precipitation (that impacts the rusting of mounting structures), wind speeds, snow etc. dictate the frequency of cleaning.
Satish Pandey, Saurav Kumar, and Sanya Verma, "Safety First: O&M challenges in floating PV systems," *Renewable Watch*, March 28, 2023, https://renewablewatch.in/2023/03/28/safety-first-om-challenges-in-floating-pv-systems/.

17 Akanksha Tyagi, Neeraj Kuldeep, and Madhura Joshi, E*mployment Potential of Emerging Renewable Energy Technologies: Insights from the Floating Solar Industry*, CEEW, NRDC, and SCGJ, March 2021, https://www.ceew.in/sites/default/files/FPV-Issue-Brief-March2021.pdf.

18 Ministry of New and Renewable Energy (Government of India), "State-wise (Location based) installed capacity of Renewable Power," accessed on August 13, 2025, https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2026/04/20260415955675604.pdf.

19 Sustainable Alternative Towards Affordable Transportation (SATAT), "Official Portal," accessed on February 24, 2026, https://satat.co.in/satat/#/.
Ministry of Petroleum & Natural Gas (Government of India), "Compressed Bio Gas (CBG) is the need of the hour, and Government is taking all steps to promote ecosystem around it: Shri Hardeep S. Puri," October 18, 2022, https://www.pib.gov.in/PressReleasePage.aspx?PRID=1868887.

20 Ministry of New and Renewable Energy (Government of India), "State-wise (Location based) installed capacity of Renewable Power," accessed on August 13, 2025, https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2025/10/202510091262518251.pdf.

21 Ibid.

22 Ministry of New and Renewable Energy (Government of India), "Overview of Small Hydropower," https://mnre.gov.in/en/small-hydro-overview/.

23 Central Electricity Authority, Ministry of Power (Government of India), "Power Sector at a Glance: ALL INDIA", accessed on June 13, 2025, https://powermin.gov.in/sites/default/files/uploads/power_sector_at_a_glance_Feb_2025.pdf.

24 International Electrotechnical Commission, "Minigrids and microgrids," accessed on September 15, 2025, https://www.iec.ch/energies/minigrids-microgrids.

25 World Bank, "Solar Mini Grids Could Power Half a Billion People by 2030 – if Action is Taken Now," September 27, 2022, https://www.worldbank.org/en/news/press-release/2022/09/27/solar-mini-grids-could-power-half-a-billion-people-by-2030-if-action-is-taken-now.

26 Ibid.

27 Ministry of New and Renewable Energy (Government of India), *Renewable Energy Statistics 2024-25*, November 2025, https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2025/11/202511061627678782.pdf.

28 IMARC Group, *India Solar Street Lighting Market Size, Share, Trends and Forecast by Type, Application, and Region, 2025-2033*," accessed on January 16, 2025, https://www.imarcgroup.com/india-solar-street-lighting-market.

29 Ministry of New and Renewable Energy (Government of India), "Technical Specification for 12W White-LED Based Solar Street Lighting System," accessed on January 16, 2025, https://cdnbbsr.s3waas.gov.in/s3716e1b8c6cd17b771da77391355749f3/uploads/2022/12/2022122196.pdf.

30 "ALMM – Authorized Solar Module Manufacturing Capacity Rises by 2.98 GW," *MERCOM India*, June 9, 2025, https://www.mercomindia.com/almm-authorized-solar-module-manufacturing-capacity-rises-by-2-98-gw.

31 Dhruv Warrior, Vibhuti Chandhok, Abhinandan Khajuria, Shruti Gauba, and Rishabh Jain, *Strengthening India's Clean Energy Supply Chain: Building Manufacturing Competitiveness in a Globally Fragmented Market*, CEEW, September 2024, https://www.ceew.in/sites/default/files/clean-energy-supply-chains-to-build-manufacturing-competitiveness-in-renewable-energy-market.pdf.

32 Ministry of New and Renewable Energy (Government of India), "Overview of Wind Manufacturing," accessed on June 12, 2025, https://mnre.gov.in/en/wind-manufacturing/.

33 Ibid.

34 Ministry of New and Renewable Energy (Government of India), "Akshay Urja Portal," accessed on June 16, 2025, https://akshayurja.gov.in/res/pm-kusum.

35 Defence Research and Development Organisation, Ministry of Defence (Government of India), "Indigenous Bio-digester technology developed by Defence Research & Development Organisation," accessed on June 4, 2025,http://drdoficciatac.com/Biodigester/aboutus.asp .

36 Ministry of New and Renewable Energy (Government of India), "Overview of Biogas Programme (Phase-I) for FY 2021-22 to 2025-26," accessed on June 12, 2025, https://biogas.mnre.gov.in/about-the-programmes.

37 Akanksha Tyagi, Arvind Poswal, Akanksha Golchha, Charu Lata, and Deepak Rai, *India's Expanding Clean Energy Workforce: 2022* Update, CEEW, , NRDC, and SCGJ, February 2023, https://www.nrdcindia.org/pdf/NRDC%20-%20Jobs%20report%20Feb%202023_Final_04022023.pdf.

38 "AI and Automation in the Renewable Energy Sector," *Industrial Automation*, May 25, 2024, https://www.industrialautomationindia.in/articles/ai-and-automation-in-the-renewable-energy-sector.

39 Femi Ajewole, Ani Kelkar, Dylan Moore, Emily Shao, and Manju Thirtha, "Unlocking the industrial potential of robotics and automation," *McKinsey & Company*, January 6, 2023, https://www.mckinsey.com/industries/industrials-and-electronics/our-insights/unlocking-the-industrial-potential-of-robotics-and-automation.

40 Emilia Filippi, Mariasole Bannò, and Sandro Trento, "Automation technologies and their impact on employment: A review, synthesis and future research agenda," *Technological Forecasting & Social Change*, no. 191 (June 2023), https://www.sciencedirect.com/science/article/pii/S0040162523001336.

41 Adani Green Energy Limited, *O&M Excellence Through ENOC*, February 2021, https://www.adanigreenenergy.com/-/media/Project/GreenEnergy/Investor-Downloads/Analyst-Meet-Dynamic/February-2021---O-and-M-Excellence-through-ENOC/OM-Excellence-through-ENOC.pdf.

42 CID Editorial Team, "Suzlon Unveils Smart Blade Plants to Drive Next-Gen Manufacturing Transformation," *Chemical Industry Digest*, December 6, 2025, https://chemindigest.com/suzlon-unveils-smart-blade-plants-driving-transformation/.

43 Arpan Sheth, Navneet Chahal, Matthew Spacie, and Jayant Rastogi, *From Aspiration to Action: Building India's 400 Million Women Workforce*, Bain & Company and Magic Bus, 2024, https://www.bain.com/globalassets/noindex/2024/bain_magic_bus_report_from_aspiration_to_action_building_indias_400_million_women_workforce.pdf.

44 Irfan Sofi, Sarfraz Ahmed, and Dil Pazir, "Gender Diversity at the Workplace and Industrial Productivity: Empirical Evidence from Indian Formal Manufacturing Sector," *Journal of Quantitative Economics*, vol. 23 (January 2025): 561-576, https://www.researchgate.net/publication/388223007_Gender_Diversity_at_the_Workplace_and_Industrial_Productivity_Empirical_Evidence_from_Indian_Formal_Manufacturing_Sector.

45 International Finance Corporation, "Gender x Climate: Pursuing Gender-Inclusive Climate Investments," 2024, https://www.ifc.org/content/dam/ifc/doclink/2024/pursuing-gender-inclusive-climate-investments.pdf.

46 National Sample Survey Office, Ministry of Statistics and Programme Implementation (Government of India), *Annual Report, PLFS, 2023-24*, September 23, 2024, https://www.mospi.gov.in/sites/default/files/publication_reports/AnnualReport_PLFS2023-24L2.pdf.

47 International Renewable Energy Agency, *Renewable energy: A Gender perspective;* Second edition, 2025, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2025/Oct/IRENA_SOC_Renewable_energy_gender_perspective_2Ed_2025.pdf.

48 Sunaina Kumar, "Women and STEM: The inexplicable gap between education and workforce participation," *Observer Research Foundation*, January 24, 2024, https://www.orfonline.org/expert-speak/women-and-stem-the-inexplicable-gap-between-education-and-workforce-participation.

49 International Energy Agency, *World Energy Investment 2025*, 2025, https://iea.blob.core.windows.net/assets/1c136349-1c31-4201-9ed7-1a7d532e4306/WorldEnergyInvestment2025.pdf.

50 Priyatam Yasaswi, Divya Gaur, and Abhishek Jain, *How Decentralised Renewable Energy-powered Technologies Impact Sustainable Livelihoods: Findings from the Ground*, CEEW, April 2025, https://www.ceew.in/sites/default/files/ceew-dre-powered-technologyweb.pdf.

51 Santosh Kumar, Sarla Meena, and Saurabh Kalia, "PM Surya Ghar: Muft Bijli Yojana (Targeting 1 Crore Solar Installation by 2027)," *Ministry of New and Renewable Energy*, December 5, 2024, https://www.pib.gov.in/PressReleasePage.aspx?PRID=2081250.

52 Ministry of New and Renewable Energy (Government of India), "Physical Achievements: Programme/Scheme wise Cumulative Physical Progress," (add accessed on date here if possible), https://mnre.gov.in/en/physical-progress/.

53 As per consultations with MNRE.

54 Ministry of New and Renewable Energy (Government of India), "Overview of Wind Manufacturing," accessed on June 12, 2025, https://mnre.gov.in/en/wind-manufacturing/.

55 Arjun Joshi, "Trained Workforce Shortage Imperils India's Renewable Energy Sector," *MERCOM India*, August 13, 2025, https://www.mercomindia.com/trained-workforce-shortage-imperils-indias-renewable-energy-sector.

56 Akanksha Tyagi et al., *India's Expanding Clean Energy Workforce: Opportunities in the Solar and Wind Energy Sectors*, CEEW, NRDC, and SCGJ, January 2022, https://www.ceew.in/sites/default/files/Green-Jobs-Report-Jan27.pdf.

57 Ministry of New and Renewable Energy (Government of India), "Opportunities in the Green Economy: Skilling and Jobs in Renewable Energy," (presented at the Fourth `National Conference of Chief Secretaries, 13-15 December 2024).

58 U.S. Department of Energy, *United States Energy & Employment Report 2023*, June 2023, https://www.energy.gov/sites/default/files/2023-06/2023%20USEER%20States%20Complete.pdf.

59 International Renewable Energy Agency, and International Labour Organization, Renewable energy and jobs: *Annual review 2025,* 2026, https://www.irena.org/-/media/Files/IRENA/Agency/Publication/2026/Jan/IRENA_SOC_RE_and_jobs_2026.pdf.

60 Jay Rutovitz, Elsa Dominish, and Jenni Downes, *Calculating Global Energy Sector Jobs: 2015 Methodology Update*, Prepared for Greenpeace International by The Institute for Sustainable Futures, University of Technology Sydney, August, 2015, https://opus.lib.uts.edu.au/bitstream/10453/43718/1/Rutovitzetal2015Calculatingglobalenergysectorjobsmethodology.pdf.

61 Jay Rutovitz et al., *Renewable Energy Employment in Australia: Methodology*, Prepared for the Clean Energy Council by the Institute for Sustainable Futures, University of Technology Sydney, June 2020, https://opus.lib.uts.edu.au/bitstream/10453/143772/2/RE-Employment-methodology-FINAL.pdf.

62 Department of Economic Affairs, Ministry of Finance (Government of India), *Notification of the National Skill Qualification Framework (NSQF)*, December 27, 2013, https://www.nqr.gov.in/sites/default/files/NSQF%20Gazette%20Notification.pdf.